The PLANS of the various Lakes and Rivers between Lake Huron and the River Ottawa, shewn in the Index Maps bound up in the volume, will be found in the Atlas accompanying the Report.

To Professor J. D. Whitney
with the respects of
W. E. Logan

GEOLOGICAL SURVEY

OF

CANADA.

REPORT OF PROGRESS

FOR THE YEARS 1853-54-55-56.

Printed by order of the Legislative Assembly.

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1857.

GEOLOGICAL SURVEY OF CANADA.

MONTREAL, *March*, 1857.

SIR,

I have the honor to request that you will do me the favor to present to His Excellency the Governor General, the accompanying Reports, showing the progress made in the Geological Survey of the Province, in the years 1853, 1854, 1855 and 1856.

The Reports are accompanied by Maps, in eleven lithographed sheets, shewing the explorations of the Muskoka, the Petewahweh, the Bonne-Chère, the South-West Branch of the Madawaska, and the sources of the Ottonabee; and by three Maps in manuscript, one of them a large one, illustrating Lake Nipissing and several rivers of the surrounding country.

All the Maps are required for the proper understanding of the Reports.

I am, Sir,

Your most obedient servant,

W. E. LOGAN,

Provincial Geologist.

To the Hon. T. Lee Terrill,

Provincial Secretary,

&c., &c., &c.

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REPORT OF PROGRESS OF THE GEOLOGICAL SURVEY OF CANADA,

FOR THE YEARS 1853-54-55-56.

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This volume contains a map illustrating the distribution of the Laurentian limestones, as described in the Report of Sir W. E. Logan; a reduced map of Mr. Murray's explorations; and a map of Anticosti, explaining Mr. Richardson's Report. It is also accompanied by an atlas, containing twenty sheets by Mr. Murray and two sheets by Sir W. E. Logan, embracing the results of their surveys of the region between Lake Huron and the Ottawa River.

TO HIS EXCELLENCY

SIR EDMUND WALKER HEAD, BART.,

ONE OF HER MAJESTY'S MOST HONORABLE PRIVY COUNCIL,

Governor General of British North America,

AND

CAPTAIN-GENERAL AND GOVERNOR-IN-CHIEF

IN AND OVER

THE PROVINCES OF CANADA, NOVA SCOTIA, NEW BRUNSWICK, AND THE ISLAND OF PRINCE EDWARD,

AND VICE-ADMIRAL OF THE SAME.

MONTREAL, 31*st* *March*, 1857.

MAY IT PLEASE YOUR EXCELLENCY:

Though the duties assigned to me in the years 1854 and 1855, in making such a collection of the economic minerals of Canada as the occasion required, and in displaying them before Europe at the Industrial Exhibition of Paris, have greatly tended to spread a knowledge of that branch of the resources of the Province, and a general acquaintance with her geology, they have prevented me from placing before Your Excellency, at regular intervals, Reports of the progress effected in the Survey committed to my charge. I have now, in consequence, the honour to transmit to Your Excellency the accumulated Reports of my colleagues, Mr. Murray and Mr. Hunt, for the years 1853, 1854, 1855 and 1856, with the Reports of Mr. Billings and Mr. Richardson, for the last season.

The Reports of Mr. Hunt comprehend various investigations of the lime-feldspar rocks and their associated minerals of the Laurentian formation; researches on the composition of the waters of the Ottawa and St. Lawrence, and various mineral springs; examinations of the serpentines and other metamorphic rocks of the Eastern townships, and of a series of traps

and intrusive rocks. Having been appointed one of the jurors of the class comprehending minerals at the Paris Exhibition in 1855, his Report for that year is devoted to some chemical and mineralogical considerations connected with it, having special reference to our native products and industry.

Mr. Richardson's Report relates to an exploration of the Island of Anticosti, the palæontological results of which, with a descriptive list of various new species of organic remains, constitute the subjects treated in the Report of Mr. Billings.

During the four years mentioned, Mr. Murray's labors were devoted to explorations of the country lying between Lake Huron and the Ottawa River. In 1853 he, in the first place, ascended the Muskoka, discharging into Georgian Bay, and descended the Petewahweh to Lake Allumette, on the Ottawa; he then ascended the Bonne-Chère, and passing from it to the Madawaska, and ascending the York or South-West Branch of the stream, crossed various tributaries of the Ottonabee River, and came out by Balsam Lake; thus making two traverses across the country, and completing a lineal distance of about 500 miles. In 1854 he examined the Meganatawan River, emptying into Lake Huron, south of the French River, and commenced an exploration of Lake Nipissing, the circuit of which he completed in 1855. With the exception of the tributary sources of the Ottonabee, which were only sketched, the rivers mentioned and the shores of Lake Nipissing were measured topographically, by the aid of Rochon's micrometer telescope, and the maps resulting from the measurements of 1853 and 1854, having been engraved on stone, on the scale of an inch to a mile, accompany the Reports. These maps occupy eleven sheets, and others now in hand, representing Lake Nipissing and the work resulting from the last season's investigation in the same general district, requiring as many more sheets, will follow so soon as they are completed.

Although on these maps are marked all the rock masses met with, yet representing mere lines of exploration, they are not sufficient to give the details of the physical structure of the district. They give, however, a general idea of the larger groups to which the formations prevailing belong, and will

afford many facts constituting valuable points from which to start in prosecuting further investigation. They, at any rate, present prominent geographical features in a hitherto undelineated and little examined part of the country,—a knowledge of which may become of importance in the progress of its settlement, and they are consequently deemed worthy of publication.

LAURENTIAN FORMATION.

Mr. Murray's lines of exploration traverse for the most part those rocks which, in Canadian geology, have been termed the Laurentian system. They are the most ancient yet known on the continent of America, and are supposed to be equivalent to the iron-bearing series of Scandinavia. Stretching on the north side of the Saint Lawrence from Labrador to Lake Superior, they occupy by far the larger share of Canada, and they have been described in former Reports as sedimentary deposits in an altered condition, consisting of gneiss interstratified with important bands of crystalline limestone. The gneiss proper, when it comes near to the surface, yields but an indifferent soil, while the soil derived from the limestones, which are usually in an easily disintegrating condition, is of a most fruitful description. The farms which have been established upon the Laurentian formation, run almost wholly upon the limestones and their associated strata, and afford a pretty distinct proof that the distribution of these calcareous bands being once known, it would not be difficult to determine in what direction it would be most judicious to push settlement. It is also in contact with these limestones, or near them, that the iron ores are found, which so prominently characterise the Laurentian series, as well as the lead-bearing veins belonging to it; and as the limestones possess external and internal characters, which render them more conspicuously distinct from the gneiss than any of the component members of the gneiss are from one another, they afford the least difficult means of tracing out the physical structure of the Laurentide district.

The distribution of the limestones therefore becomes a subject both scientifically and economically important, but it is

one, the investigation of which will require a great amount of patient labor. To determine the superposition of the component parts of such an ancient series of rocks as the Laurentian, is a task which has never yet been accomplished in geology, and the difficulties attending it arise from the absence of fossils to characterise its different members. Bands of the crystalline limestone are easily distinguished from bands of the gneiss, but it is scarcely possible to know, from mere local inspection, whether any mass of the limestone in one part is equivalent to a certain mass in another. They all resemble one another more or less lithologically, and although masses are met with running for considerable distances rudely parallel to one another, it is not yet certainly known whether the calcareous strata are confined to one group often repeated by sharp undulations, or whether, as is probable, there are several groups separated from one another by heavy masses of gneiss. The dips avail but little in ascertaining this, for in the numerous folds with which the formation is wrinkled, these dips must very frequently be overturned, and the only reliable mode of pursuing the investigation, and of making even the limestones available in working out the physical structure, is patiently and continuously to follow the outcrop of each important mass in all its windings, as far as it can be traced, until it becomes covered up by superior unconformable formations, is cut off by some great dislocation, or disappears by thinning away to nothing. A labor such as this, in a district without roads, and the topography of which is scarcely yet known, with a surface much broken by the unequal wear of its rocks, and still covered by forest, must necessarily require much time.

The occurrence of the crystalline limestones in many distinct localities, ranging from the borders of Lake Huron to the River Saguenay, is well known; but no long continuous outcrop of any individual group of these calcareous strata, that I am acquainted with, has yet been shewn, and with the exception of the connection of the different portions of that incidentally traced by Mr. Murray in its windings through a part of the township of Bedford in 1852, while he was occupied in fol-

lowing out the junction of the fossiliferous and unfossiliferous rocks between Kingston and Lake Simcoe, it had not been with certainty proved that any two nearly parallel ranges of the rock could be traced to a junction.

My attention was devoted in the season of 1853 to the examination of those masses known to exist in the township of Grenville, and the facts then ascertained in that and neighboring townships, with the addition of others which have been determined since my return from Europe, will constitute the subject of the personal explorations I have to report to your Excellency on the present occasion.

Distribution of the Crystalline Limestones.

The limit of the Laurentian formation in the vicinity of Grenville has been given in a former Report, where it has been stated that it comes upon the Ottawa, a short distance above the village. Within four miles above the village, on or near the road running round the bay there presented by the left bank of the river, two important bands of the crystalline limestone emerge from beneath the fossiliferous strata underlying the flat country overlooked by the Laurentide hills. These bands, separated less than two miles from one another, rise into the flank of the hills, which exhibits a section transverse to the general strike of the formation in that part. One of the bands is seen in the third range of the township, on the line between the twelfth and thirteenth lots, and the other on the Calumet River, on the sixteenth and seventeenth lots of the second range.

The space between them is occupied by gneiss, the banded structure of which is visible in a vast number of places, but a large part of the rock is coarse-grained; the feldspar being in individuals, frequently attaining an inch and sometimes more in diameter, while the mica and the quartz often accompanied by hornblende, and the former sometimes replaced by it, are distributed among the feldspar in such a manner as to give a reticulated aspect to the surface. Beds of this character are sometimes thin, but when thick and massive, which they usually

are, they might upon a first inspection be mistaken for igneous instead of altered rocks. Upon a careful study of the case, however, it will be perceived that this reticulated structure is accompanied by an obscure arrangement of the meshes of the net-work into parallel lines, which are found to be conformable with the more distinctly banded portion of the strata. The more distinctly banded part is possessed of less feldspar than the reticulated portion, and often presents layers of quartz rock, sometimes nearly pure, which seem to become more abundant on approaching the limestones. The rocks, for some distance on the outside of the two ranges of calcareous strata, bear much the same character as those between them, the reticulated gneiss being perhaps more abundant and more massive.

In the mountain flank the two calcareous bands are almost exactly parallel to one another, running about N. N. E., and they both, as well as the gneiss between them, dip with many irregularities to the westward. They keep nearly parallel for several miles into the interior, but it will be expedient to follow out one of the bands continuously.

The calcareous exposures on the Calumet are comprised within the space of between 200 and 300 yards across the stratification, and they can be traced up the river from the position mentioned on the bay road in the second range, to the quarry in the third range, where Mr. Charlebois some years ago erected a mill for sawing and polishing the limestone as marble, and where, as was described in a former Report, the rock, which is white, is much marked by spots and patches of green serpentine. The quarry is situated towards the front of the sixteenth lot, close upon the west side of the Calumet, the channel of which is paved with the limestone, while very little removed from the opposite side, the gneiss, limiting the calcareous group of strata to the eastward, rises in a heavy mass, parts of which, not far from the spot, are marked with red garnets.

If a line be carried from this spot in a direction W. N. W.*

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* The bearings given in this Report are magnetic; the variation of the compass is about ten degrees west.

across the seventeenth lot to the road running up between it and the eighteenth, several exposures of limestone, in addition to those already mentioned, will be met with. A little north of the line, at least four are seen between Mr. Profit's house (which stands in about the middle breadth of the seventeenth lot) and the road, separated from one another by beds of pyroxenic gneiss and quartz rock, and about two acres west of the road a precipice of reticulated gneiss presents itself, limiting the whole. The transverse breadth from the marble quarry to this precipice is not much under half-a-mile. Few of the dips are less than fifty degrees, and many of them reach seventy and eighty. But as the breadth stated greatly exceeds that farther on, it is probable that a considerable part of it is due to the repetition of beds through undulations, and in estimating the thickness of the group an allowance must be made for them. It appears to me probable, however, that a liberal one would not reduce the thickness to less than 1000 feet.

From the front of the third range, the calcareous group can be traced to the rear of the fourth (nearly two miles), by several considerable exposures of limestone and the limiting gneiss. In this distance the strike is nearly N. N. E., and the belt runs the whole way upon the line between the seventeenth and eighteenth lots. Close on the rear of the seventeenth lot, it is seen on the farm of Mr. E. Connely. Here four beds of limestone appear to be separated by beds of feldspar and quartz rock, the former weathering opaque white, and much studded with patches of augite or pyroxene. The thickest bed of the limestone appears to be on the west side of the group, and a heavy bed of quartz rock, about fifty yards wide, intervenes between it and the gneiss. Of the gneiss there is a wide exposure on the west side, between the quartz rock and the River Rouge. It measures 800 yards across the stratification, exhibiting distinctly marked beds, very regular in strike, but varying in inclination from fifty-six to seventy-seven degrees. Including the quartz rock, the breadth across the limestone group is about 500 yards. There are some twists in it conspicuously displayed on the east side, but it is probable that the thickness of the whole does not fall short of the 1000 feet already stated.

In the next half-mile the calcareous belt is cut by dykes of greenstone trap, with a well-marked transverse columnar structure. There appear to be two of importance, and one of these, with a breadth of fifty yards, has been traced at a right angle across the stratification, for a distance of three-quarters of a mile to the eastward. Although there are no exposures of the limestone, sink-holes in the same bearing as before, indicate its course, still on the line between the seventeenth and eighteenth lots; and by means of them it is traced to a position in a valley where its breadth is well bounded by precipices of the gneiss on each side. In this valley it crosses the fifth range, still in the same relation as before to the lots; but no exposures of it are met with. On the west side of the valley, however, within a hundred and fifty paces of the rear of the range, there is exposed an enormous mass of white quartz rock. It is distinctly divided into beds, and with a transverse breadth of 150 yards it has a dip N. 80° W. $<$ 61°. This would give it a thickness of 400 feet, and between it and the gneiss on the east side of the valley there is a breadth of exactly ten chains, which, assuming the dip to be the same, would give a thickness for the calcareous part of 580 feet, making the whole thickness much the same as before.

This part of the valley is quite flat and even; it possesses a deep rich soil, and being wholly free from boulders, gives fine arable land. It continues of this character for three-quarters of a mile, and with a uniform breadth; it has a bold gneiss cliff on the east and the quartz rock on the west side. But though there is not a single exhibition of the calcareous strata, a fine spring which issues from the soil near the house of Mr. Fahlen, on the seventeenth lot of the sixth range, is so charged with carbonate of lime that the water quickly leaves a coating of it on the utensils in which it is boiled for culinary purposes.

Towards the rear of the sixth range the valley gradually opens to double its last breadth, by a bend in the gneiss on the east side, and while the quartz rock is still conspicuously displayed on the west, an exposure of the limestone occurs close by the gneiss on the other, in the vicinity of the front post, between the fifteenth and sixteenth lots of the seventh range.

Though the strike of the belt up to this point is very nearly the same as at the commencement, it has ceased to hold the same relation to the lots as at first, in consequence of irregularities in the original survey of the township, which give them a very marked turn to the left. Beyond this the strike veers a few degrees farther from north, and after a gentle sinuosity to the east in crossing the eighth range, the less northern strike is maintained to nearly the centre of the thirteenth lot of the eleventh range, which is the last of the township, the belt running in a valley all the way. But from the southern half of the line, between the fourteenth and fifteenth lots of the ninth range, on which there are large exposures of the calcareous strata, there is a projecting spur of the limestone running nearly south in another valley, in which the rock, often exhibited to view, reaches the front half of the twelfth lot of the eighth range, the distance being about a mile and a-half.

On the line between the tenth and eleventh ranges the limestone is largely displayed across the thirteenth lot, while no other rock is seen in place, and the exposures extend about 200 yards beyond the lot on each side. The breadth of the limestone would thus be from forty-five to fifty chains, and from this as a base, its sides come to a point near the centre of the thirteenth lot of the eleventh range, where it exhibits a somewhat truncated apex, surrounded by gneiss, with some beds of quartz rock between.

From this the trend of the belt is south, which it maintains to the line between the sixth and seventh ranges, the distance being about five miles. It underlies a valley the whole way, bounded by a mountain of gneiss on each side, that on the west separating it from the valley in which the belt was followed northward. Across the ninth range it has a breadth of about 700 yards, being interstratified in some parts with quartz rock, and on the north half of the twelfth lot, occupied by Mr. Wilson, a band of quartz rock occurs on the west side, with gneiss beyond, studded with garnets; but no bands of quartz rock were observed between the limestone and the gneiss on the east side of the valley.

Across the eighth range the belt widens to 1000 yards, by a

bend on the west side; and in this measure are included on that side some bands of quartz rock and dolomite holding grains of serpentine. These bands and the bend mentioned occur about half-way across the range, where the hill on the west side being worn down, a transverse valley presents itself, reaching to the spur of limestone which has been described as projected southward from the eastern valley. In this transverse valley very little gneiss was met with; but white quartz rock and feldspathic rock are seen in several spots nearly all the way, the distance between the limestone exposures nearest to one another, in the two belts, being a little over half-a-mile.

A little south of the line, between the seventh and eighth ranges, the valley we are tracing, and the limestone contained in it, are suddenly contracted again to about 700 yards, leaving a spur of the calcareous rock on the west side in the ninth lot. Thus reduced the band crosses the seventh range, and then changing its north and south strike, traverses the sixth, bearing about S. 30° W., in which direction it runs from the seventh to the tenth lot. All along the south-east side, beds of quartz rock are seen, becoming more and more interstratified with gneiss as they recede from the limestone, but their continuity is broken in the south-east corner of the ninth lot by an intrusive mass of syenite, which will be spoken of farther on. Quartz rock accompanies the calcareous band on the north-west side also, with much constancy, though the frequency and the thickness of the beds are perhaps not so great.

From the line between the fifth and sixth ranges, the east side of the belt again gradually turns south, and in this bearing there are large exposures of calcareous rock extending to the south half of the ninth lot in the fourth range, a distance of a mile and three-quarters. They are embraced in an area which has a breadth of about 850 yards, the two sides of which are nearly parallel. Well marked beds of quartz rock, separated by thin layers of gneiss, follow the rim of this area, with a breadth varying from 150 to 200 yards, and rounding the southern extremity again return with the limestone to the line between the fifth and sixth ranges, which they reach on the eleventh and twelfth lots; but between the limestone at this point and

the position from which we started on the same range line on the tenth lot, there appears a projecting mass of quartz rock and gneiss, which extends southward about thirty chains on the line between the tenth and eleventh lots.

The limestone continues northward, with a few degrees of easting, across the sixth range, and about twenty-five chains into the seventh, and here again turning in a deep triangular recess of the gneiss mountains, it maintains a S. S. W. course on the twelfth and thirteenth lots across all the ranges in succession, to the middle of the third. The eastern margin is pretty straight, and in this stretch of three and a-half miles it runs exactly parallel to the western belt; but on the west side there are some irregularities. From the sixth to the middle of the fourth range the belt gradually widens, attaining at the latter part a breadth of three-quarters of a mile opposite to a transverse valley, reaching across from the eastern to the western belt, and affording a channel for the united branches of the Calumet. A portion of the measure given to the eastern belt, however, is occupied by a sub-lenticular shaped mass of gneiss of about a mile and a-quarter in length, by a breadth of a-quarter of a mile where widest. Between it and the gneiss on the east, the band of limestone is narrow, not exceeding 200 yards, and while the gneiss on each side of it meets the limestone with a straight face, the limestone itself appears to be much twisted and broken, as are also some beds of quartz rock, whose place seems to be on the east side.

Before reaching the line between the third and fourth ranges, the limestone suddenly narrows to about 150 yards, but increases to 250 yards before it disappears under the fossiliferous strata at the foot of the Laurentian hills, where it was indicated at the commencement of the description as constituting one of the two bands rising into their flank.

These two bands are thus shewn to be traceable to a union, and in reality to constitute but one; and as the dips which they shew, in so far as they can be measured by a clinometer, have in almost all parts, on both sides, a more or less westward bearing, it becomes a question to what form the belts are related in the physical structure of the district. As the formation is

beyond a doubt of a stratified character, these belts of limestone are the outcrop of an undulating sheet, the ridges of which have been worn down; but in the horizontal section of an undulating surface, similar forms in the distribution of the horizontal rim may be derived from the anticlinal or synclinal part of the undulation, and it is to be determined in the present instance to which of these the area between the belts belongs.

Allusion has been made to an exposure of intrusive syenite, which touches one part of the eastern calcareous band in the south-east corner of the ninth lot of the sixth range. This belongs to a mass of the same rock which has an area of about thirty square miles in the townships of Grenville, Chatham and Wentworth. At its western extremity it presents a north and south face of a mile and a-half, running parallel to the calcareous area which has been described as stretching to the southern half of the ninth lot of the fourth range of Grenville, from the east side of which area its distance is from a-quarter to half-a-mile. The south-west corner is on the eighth lot of the same range, in which it does not reach quite so far south as the limestone does in the ninth. From this its southern face extends to the eleventh lot of the seventh range of Chatham, in a general straight line, shewing however a few indentations. The distance is eight and a-half miles, and the rock constitutes a continuation of the flank of the mountains overlooking the fossiliferous plains, for a considerable part of the way. On the north-east side it is limited by the West Branch of the North River, from the position last mentioned to the middle of the tenth range of Chatham, on the line between the twenty-third and twenty-fourth lots; and to the middle of the twenty-seventh lot of the same range, from the position where it was first mentioned in Grenville, its boundary runs E. N. E. and W. S. W. Between the two points indicated in the tenth range of Chatham there is a distance of about a mile, and from this breadth as a base, the sides of the mass gradually approach as it runs in a N. N. E. direction into Wentworth, in which its precise termination has not been ascertained, though it is probable it does not extend very far.

The intrusion of such a mass of igneous rock as this can scarcely fail to have had a considerable effect in modifying the attitude of the strata which surround it. The crystalline condition of the syenite shews that it was slowly cooled under great pressure, and we cannot now say whether it was a deep seated part of an outburst which reached the surface, as it was then constituted, or whether it was originally overlaid by masses of gneiss and limestone which have since been worn away. In either case the probability is, that it would give to the strata now surrounding it an anticlinal form. It seems probable, therefore, that the western dip, belonging to the eastern band of limestone, where it approaches the western extremity of the syenite, is a true one, and that the form between the bands is synclinal. This appears to be corroborated by the fact that where transverse valleys occur between them, the wearing down of the intermediate gneiss widens the calcareous bands, particularly the east one, and narrows the interval.

The calcareous sheet having thus the form of a trough, the western dip of the western outcrop must be an overturn; and the two spurs of the rock which point to one another, the one turning south from the western belt, and the other north from the eastern, must constitute a subordinate anticlinal. Without reference to minor corrugations, the general form of the area would be that of two troughs joined together, each about a mile and a-half wide, with an overturn dip on the west side, the one trough running north and south, and the other, as far as unconcealed by the superior fossiliferous strata, south-south-west and north-north-east. The accompanying wood-cut gives a vertical section of the form.

a, crystalline limestone; b, gneiss and quartz rock.

Though the northern extremity of this double calcareous trough crops out in the middle of the thirteenth lot of the eleventh range, the depression formed by the confluence of the two valleys coinciding with its sides, does not terminate there. It runs northward into Harrington, and while the waters connected with the Grenville part of the depression run southward, yielding their contribution to the Calumet River, those in the Harrington part flow northward across the township, and join the River Rouge beyond the northern boundary.

Across the first and second ranges of Harrington the depression runs north, in a direct continuation of the east side of the calcareous trough just described; and after we leave this trough and traverse but a short interval of gneiss, calcareous rocks are again met with. They occupy a small portion of the rear of the thirteenth and fourteenth lots of the last range of Grenville, and enter on the eighth and ninth of the first range of Harrington, the eighth lot in the occupation of Mr. Xavier O'Brien and the ninth of Mr. W. Fox. Other exposures are met with more than half-way across the range, and it appears probable that the whole of them belong to a calcareous area which may reach Slavery Lake on the tenth and eleventh lots of the second range. In length the area would thus be about a mile and a-half, and its breadth near the town line of Grenville and Harrington under half-a-mile, gradually diminishing northward. From the relation of this area to the Grenville trough, its form would of course be, like that, synclinal.

The gneiss-bound valley in which the area lies, continues in the same directly north bearing, for another mile, to the middle of the third range on the eleventh lot; then turning N. E. it runs about a mile in that direction and splits into two valleys, one continuing to bear in the same N. E. direction, or perhaps a little north of it, and the other about N. 80° E. Both these vallies are paved with limestone. In the former the rock occupies a breadth of nearly a mile between two lakes, the one called McCulloch's Lake, from the name of the only settler on its banks, and the other the Big Lake, because it is the largest in Harrington; beyond them it has been followed

to the ninth range of the township, while I have lately received intelligence of its extending, as was to be expected, in the same course into Montcalm. In the opposite direction, however, exposures have not yet been met with farther south than the brook emptying McCulloch's Lake into Big Lake.

In the other valley the rock has been traced from the head of Big Lake, on the land of Mr. Donald Fraser in the front of the eighth lot of the fifth range, to the first on the line between the fifth and sixth ranges of Harrington, and thence to the next lot, that of Mr. A. Fraser, which is the twenty-eighth of the seventh range of Wentworth. The distance is about three miles, the bearing, as stated, N. 80° E., and the breadth of the band varies from about one-quarter to three-quarters of a mile. The house of Mr. Fraser, standing on the limestone, is situated on a beautiful sheet of water called Gate Lake, which has an east and west length of about a mile, with a breadth of half-a-mile. The lake lies chiefly in the sixth range of Wentworth, but near to Fraser's house there is a part of it in the seventh. The limestone is seen on both sides of the lake as well as at the lower or western end of it, where it forms a natural bridge, beneath which occurs the exit of the lake, close upon the line between the two townships which have been named.

From this lake the rock takes a turn to the N. E., towards Sixteen Island Lake, a long stretch of water extending from the rear of the first range in the township of Montcalm to the twenty-fifth lot of the eighth range of Wentworth, and emptying by a considerable brook into Gate Lake, which by the calcareous valley we are following, is again tributary to Big Lake, and ultimately to the River Rouge. The limestone reaches the lower end of Sixteen Island Lake, and occupies its eastern side to the twenty-third lot of the ninth range, where it turns eastward from the lake; but beyond this it has not yet been traced.

From this position to the upper end of Big Lake the distance is about six miles, and the excellence of the soil prevailing in the valley has caused partial clearings to be effected in almost every lot in that part of it which is in Harrington. Between

the upper end of Big Lake and the mouth of McCulloch's Brook, in the other valley, there is a distance of about half-a-mile occupied by a ridge of gneiss, exposures of which are seen on the east side of what is called the Narrows of Big Lake, as well as in a knoll occurring on the west side, at the very narrowest part, where the distance across the water is not over fifty yards. The position of this knoll is near the line between the ninth and tenth lots, and somewhat south of the middle of the fifth range. In addition to gneiss, it shews beds of quartz rock dipping N. 65° W. <60°, which would give a strike running with the valley, and between the knoll and the flank of the western gneiss which bounds the valley, there is a flat marshy surface with a breadth of some five or six acres.

In this flat area no exposures of limestone have yet been met with, but it appears to me very probable that it is underlaid by this rock, which, to support the view I am disposed to take of the structure of the two valleys, would require to be projected from each to a junction in the one from which they branch. If this be confirmed, it will at once be concluded that the distribution of the limestone in this part indicates the continuance of the synclinal form traced through Grenville, with a turn to N. E. in its axis, from the third range of Harrington.

The gneiss on the west side of the synclinal constitutes a well marked bold and rocky ridge, which extends in a line nearly straight from the front of Grenville to the rear of Harrington, the distance being about twenty miles and the bearing N. N. E. The ridge is not often broken through by transverse valleys, and where such occur, they appear for the most part to result from the weakness accompanying greenstone dykes.

In the front of Harrington this ridge has a breadth varying from three-quarters of a mile to twice that measure, and on the west side of it there occur two long areas parallel to it and to one another, presenting the form of valleys, which include so many exposures of limestone as to make it evident they are underlaid by the rock. The more eastern of these extends for a short distance within the last range of Grenville,

to nearly the rear of the fifth range of Harrington, some five miles. It has a breadth of nearly half-a-mile in the south part, which gradually diminishes northward. From its extremities there flow two brooks in nearly the same line, but in opposite directions, and these joining in the second range, the united stream, Dhure's Brook, crosses the more western area and reaches the Rouge about a mile beyond. The northern extremity of the western area also occurs in the fifth range, from which the exposures of the rock gradually assume a wider spread, until reaching Dhure's Brook, where they occupy upwards of a mile in breadth. South of this brook about half-a-mile, the rock is seen near Mr. Dugald Campbell's house, but farther on the area runs under a thick, flat and fertile covering of clay, and its limit in that direction has not been ascertained, but it probably occurs a little south of the town line of Harrington.

The northern extremities of these two parallel areas are about a mile asunder, and they are separated by a bold and rocky ridge of gneiss, which gradually narrows and dies down going south, terminating altogether less than half-way across the second range. A less prominent ridge makes its appearance in the same line south of Dhure's Brook, and it is probable that on this brook the two calcareous areas are connected.

The prevailing dips in connection with these two isolated areas being still to the westward, it will be necessary to ascertain the distribution of others farther to the north, before the form to be given to them in the physical structure, can be determined with certainty. They may be parallel anticlinals or parallel synclinals. If the former, they would belong to a lower group of calcareous strata than those already described; but if the latter, they would be only a repetition of them, and this view I am at present inclined to adopt.

It is probable that a smaller calcareous area which occurs on the first, second and third lots of the tenth range of Grenville, about three miles on the east side of the main synclinal, has the same relation to it. About the breadth of two lots from this patch, rises in Chatham the western side of the ridge

of syenite described as projecting northward from the main body of the volcanic rock, and pointing like a finger towards Wentworth. Close on the east side of this finger there is met with another calcareous band. The most northern exposure of it I have yet seen is on the line between the first and second ranges of Wentworth, in the twenty-second lot. It has here a breadth of about 400 yards, and can be traced obliquely across the twenty-first and twentieth lots of the first range. From this last it crosses the town line and enters Chatham upon the twenty-second lot of the twelfth range, from which it quickly sweeps round to the twenty-third, the property of Mr. Brewer, who has recently erected a kiln to burn the stone for lime.

It here becomes confined to a deep and narrow valley which gives a channel to the West Branch of the North River. Bold flanks of gneiss hem it in on both sides, that on the west being a strip between the limestone and the syenite. In this gorge the limestone may have a breadth of between 200 and 300 yards, and though not seen in its course for upwards of a mile, it maintains a straight one, running S. S. W. with the lots, across the twelfth and eleventh ranges. Several exposures of the limestone occur on the front of the eleventh range in the twenty-third and twenty-fourth lots on both sides of the West Branch, and on the same lots in the rear of the tenth range, in the vicinity of Mr. Carpenter's house.

In this part the calcareous rock comes close upon the syenite, from which emanate one or two dykes intersecting it, and as the main body of the volcanic rock rises to the south, the limestone must be either entirely cut off by it or deflected to the eastward. I am inclined to think that it is deflected; for from this point the syenite runs across the lots to the southward of east, and though I have not met with any calcareous exposures running parallel with the syenite for about two miles and a-half to the eastward, one with such a strike does then occur about the middle of the fourteenth lot of the tenth range, and the gneiss runs nearly parallel with the syenite all the way. The strike of this calcareous exposure is about E. S. E., and traced to the thirteenth lot it turns southward, crossing on it into the ninth range. About a mile farther

south it is again visible in the channel of the West Branch in the twelfth lot, near the line between the eighth and ninth ranges, a short distance from the syenite. It may proceed a little farther to the south-eastward, but in this neighbourhood it appears again to turn north, coming back to the road between the ninth and tenth ranges at the church near the line between the tenth and eleventh lots.

The breadth of the band, including several silicious beds, here extends from Mr. McArthur's house on the tenth lot to a short distance westward of the church on the eleventh, the measure being about 500 yards; while the breadth of the gneiss which separates it from the position where it crosses the road still farther west is about half-a-mile.

From the south-west corner of the tenth lot a road runs back on the lot across the tenth, eleventh and twelfth ranges of Chatham into Wentworth. It is underlaid by the limestone nearly the whole way. Across the tenth range the course of the limestone is N. N. E.; across the eleventh it inclines more to the east, and it again resumes the previous direction across the twelfth, and leaves Chatham about one lot more to the eastward than its position at McArthur's, and with a breadth increased by one-half. In the front of the eleventh range one part of the belt becomes very coarsely crystalline, shewing individuals of calc-spar of two or three inches in diameter, and it here assumes the character of a fetid limestone, emitting when rubbed an overpowering odor like that of sulphuretted hydrogen.

It constitutes a valley across these ranges, as is indicated by the coincidence with it of the course of the Big Creek, a tributary of the West Branch, nearly the whole way; but the depression is not a deep one. It becomes more marked, however, towards the rear of Chatham, across the twelfth range, in the front of which limestone is burnt by Mr. McGibbon, and it is accompanied on the east side by a conspicuous band of garnetiferous gneiss, in which the garnets, though much cracked and broken, are of a deep red color and large size.

Entering Wentworth on the eighth and ninth lots, the belt maintains its Chatham bearing across the first and the larger

part of the second range, with a pretty uniform breadth, which however includes some bands of quartz rock, and one of reticulated gneiss on the west side. It then turns to the eastward on the latter range, and crossing the lots gains the line between the fifth and sixth. On these lots it makes a right angle to the northward and passes into the third range. Up to this point it still coincides with the upward course of the Big Creek; but immediately turning eastward again, while the Big Creek inclines north, they separate, the north side of the limestone running into a short spur at the point of separation on the fourth lot.

Proceeding eastward across the third and second lots, occupied by Mr. Mann and Mr. Conlin, exposures of the limestone are found on both sides of a small lake which is tributary to the Big Creek, but on the north side of the lake there appears a lenticular-shaped mass of quartz rock which extends eastward for half its length. Beyond this lake the belt, much diminished in its breadth, leaves the third range of Wentworth and enters the third range of Chatham Gore, on the second lot of which it turns more northward and passes into the fourth range, attaining it on the third lot, where it is bounded on the north side by a band of garnet-gneiss as conspicuous as that on the opposite side in Wentworth. It returns again to the third range on the sixth lot, after presenting a very irregular and indented out-crop, through the influence of two small undulations. Still running eastward it reaches the eighth lot, where some of its beds have been burnt for lime by Mr. Parker, the proprietor of the land.

From this position, where its breadth is scarcely over a hundred yards, the calcareous belt assumes a S. W. course, and after spreading out, through the effect of small undulations, to the measure of nearly three-quarters of a mile on the eighth, seventh and sixth lots of the third range, it again contracts to its former dimensions and enters the upper end of Long Lake on the sixth lot of the second range, emerging from the lower end on the fourth lot of the first range. A bold precipice of gneiss limits the lake on the east side, which suddenly breaks off some distance beyond the exit, and the

country farther to the south becomes in general less rugged. The limestone increases in breadth a little on leaving the lake, and where it reaches the south line of the Gore on the third lot, it may measure about 200 yards.

It enters the seigniory of Argenteuil on the fifth and sixth lots, and advancing about half-a-mile, its western boundary is seen in the former near Mr. Evans' house. From this position it is with difficulty traced further south, only one exposure occurring in the next three miles. This is at about one-third of the distance, near the school-house in front of the third concession on the fifth lot, where the belt appears to have very much decreased in width.

At about a mile and three-quarters from the North River, on the Gore Road to Lachute, a trap dyke occurs running east and west; and to the south of this the limestone again appears, and can be traced all the way to the river, where it becomes covered up by the fossiliferous rocks. Before sinking beneath them, however, the band spreads into a very wide exposure and apparently changes its course, commencing to run in a north-westerly direction, but gradually turning more west; and it is traceable for about a mile and three-quarters in this bearing before it is finally concealed by the Potsdam sandstone, the strike of which is oblique to the calcareous band. In this last exposure, being conveniently situated in respect to roads, and in a neighbourhood where the fossiliferous limestone is rather arenaceous, the crystalline band is greatly burnt for lime, the principal kiln being that appertaining to Mr. McGregor.

Between the position in Wentworth where the description of this calcareous band commenced, and the position on Sixteen Island Lake where that of a previous one terminated, there is a distance of between seven and eight miles which remains unexamined. But it appears to me probable that when the investigation is further prosecuted these two bands will be found to join. Should this prove to be the case, the whole of the calcareous exposures, which we have thus followed through their distribution in Grenville, Harrington, Wentworth, Chatham, Chatham Gore and Argenteuil, to the vicinity

of Lachute will belong to one group only. The lineal distance given by its outcrop in the various windings which we have traced, is about eighty miles. The distribution shews four main synclinal forms, separated by three anticlinals, and these being comprehended in a transverse distance of eighteen miles, there would on the average be about four miles between the axes of each two. The accompanying wood cut exhibits a vertical section across them all.

a, crystalline limestone; *b*, gneiss and quartz-rock; *s*, syenite; *p*, porphyry.

Before a more extended investigation, it would be premature to say much of the general bearing or parallelism of these axes, or of the effect the intrusive rocks may have had in producing or modifying the forms; but in respect to these intrusive rocks a certain sequence in date is very conspicuously displayed, which may be here noticed. The oldest intrusive masses are a set of greenstone dykes, composed of a greenish-white feldspar and black hornblende, with a small amount of iron pyrites. Their width varies from ten to one hundred yards, and they all possess a well marked transverse columnar structure. The largest are occasionally moderately coarse-grained, and the smaller fine-grained, but they are all distinctly crystalline. Their general bearing is east and west, but the main dykes occasionally divide, a branch striking off at an angle of from twenty to forty degrees.

One of these dykes was met with cutting the limestone on the thirteenth lot of the fourth range of Grenville; its breadth was there about thirty yards, and it was followed across the limestone and the gneiss for a mile and three-quarters, in which with a few moderate zig-zags it maintained a course of S. 85° E., until it was interrupted by the syenite on the eighth lot of the range already mentioned. Across the limestone it gave a ridge, but across the gneiss it was usually found in a

depression, sometimes a very deep one. Where it mounted the side of any ridge running with the stratification, the columnar structure gave it the aspect of a flight of gigantic steps, well presenting the character from which the Swedish name of trap is derived. The columns were so truly at right angles to the plane of the dyke, that they were always a sure means of determining the underlie, which was towards the north. A branch struck off from this dyke, on the eleventh lot of the range, and after proceeding for about a quarter of a mile in the direction S. 20° E., it turned to S. 40° E., and was followed for three-quarters of a mile more, chiefly across the limestone, in a remarkably straight line to the eighth lot, where having gradually diminished from the width of eighteen yards to five, it seemed to split up into a brush-like distribution of small

NOTE.—Additional investigation since the text of this Report passed through the press, has shewn that the limestone traced to Sixteen Island Lake, instead of turning southward to join that in the front of Wentworth, near the syenite, runs north into Montcalm, as indicated on the map; also, that the limestone on the town-line between Wentworth and Chatham, near the syenite, is separated from that southward of it on the line between the tenth and eleventh ranges of the latter township, by the interposition of a mass of gneiss. From other facts, however, not yet completely investigated, it is still supposed that the different exposures of limestone, alluded to in this note, belong to the same sheet, so that the vertical section would remain a true one.

its underlie was northward.

On Mr. Donald Frazer's land, the eighth lot of the fifth range of Harrington at the head of Big Lake, a fourth was about twenty yards wide, and it was traced, for a quarter of a mile running under Mr. Frazer's house in its course; the bearing of it was N. 52° E. Another one constituted prominent points on opposite sides of McCulloch's lake towards the rear of the sixth range; it was evidently an important dyke, though its exact breadth was not ascertained. Its bearing seemed to be at about a right angle with the length of the lots, so that it would run about S. 70° E. A sixth one ran boldly out into the water at the eastern end of Gate Lake, on the twenty-

sixth lot of the sixth range of Wentworth. It might have been about fifty yards wide, and in its course in the bearing N. 46° W., it tipped the point of the next promontory. This bearing would carry it to some position on the north side of the lake at the west end, but it was not there observed. It appears to me probable that the last three dykes, though they were not traced far, will be found connected, in the relation of a main dyke with a branch emanating from it.

From the sixth lot of the fourth range of Chatham Gore, where it cut the limestone, another of these greenstone dykes was traced for upwards of two miles to the first lot of the third range of Wentworth. Its width varied from fifty to one hundred yards, but it appeared to maintain a very uniform bearing, and though an interval of seven miles is a long one at which to recognize it again, yet an exposure of greenstone on the front of the first range of Wentworth, on the division between the twentieth and twenty-first lots, is so exactly in the line, that I am disposed to consider it a continuation of the same dyke. At the latter spot it is from 110 to 120 yards wide, and about eleven chains to the westward it is cut off by the syenite.

Still another of these dykes was observed as has been mentioned in the seigniory of Argenteuil, about a mile and a-half from the North River on the road from Lachute to Chatham Gore. It appeared to be about twenty-five or thirty yards wide, and it was followed in the bearing N. 75° W., for about a mile and a-half from a point eastward of the road, to the town line of Chatham, which it crossed towards the rear of the the ninth range; and although it would require a change in its direction to bring it to a dyke seen on the road between the seventh and eighth ranges on the ninth lot, I am inclined to suppose they will be found identical. Running about west from the latter spot, it comes against the syenite in the eleventh lot of the seventh range, and is there cut off by it.

These greenstone dykes being always cut off by the syenite where they have been observed to come in contact, it is plain the syenite must be of posterior date. The area which the syenite occupies has already been described. In its litholo-

gical character the rock is very uniform, being composed for the most part of feldspar, either of some tinge of red, or a dull white, with black hornblende, and a rather sparing quantity of translucent quartz. The red tinge prevails more on the west side, the white on the east. In the spur which runs into Wentworth, mica was occasionally found to accompany the hornblende. The rock was rather coarsely crystalline in the main body, but dykes of it were sometimes observed cutting the limestone and the gneiss, in which the grain was finer, but they were never traced from any distance up to the nucleus.

The syenite was found to be cut and penetrated by volcanic rock of a porphyritic character, which is therefore of a still later date. The larger masses of this porphyritic rock consist of fine-grained, dull reddish-buff feldspar, with which is mingled a sparing quantity of fine-grained black hornblende, the mixture constituting a base in which well defined crystals of the same reddish feldspar, of various sizes from one-eighth to three-eighths of an inch, are thickly disseminated; the base is compact, presenting an impalpable grain, a conchoidal fracture, and a jaspoid aspect, with various colors, from light to dark grey, brownish-black, and dull green. In addition to crystals of red feldspar, this jaspoid base often contains a multitude of fragments of gneiss, greenstone and syenite, varying in size from small grains to masses several feet in diameter, and these are occasionally so abundant as to give the rock the features of a tufa.

The green base is rather more compact than the grey, and it does not usually contain so many imbedded crystals of feldspar, but both would afford fine material for ornamental purposes, and when the grey is very dark, approaching black, and the feldspar a decided red, the polished stone has a very beautiful aspect.

The principal mass of this porphyritic rock occupies a pear-shaped area of about 250 acres, with the small end pointing south, on the third and fourth lots of the fifth and sixth ranges of Grenville, from which, on the east side, a portion is projected into the second lot of the fifth range. The mass is wholly

surrounded by the syenite, and a large part of it constitutes a mountain or group of hills, intersected by one or two ravines. In about the centre of the mass, on the summit of one of the hills, there exists a circular depression of about one hundred yards in diameter, nearly surrounded by a tufaceous porphyritic rim of about thirty feet in height. In this depression, which is situated in the sixth range on the line between the third and fourth lots, about fifteen chains from the front, there is held a turf bog, with an even surface, from which springs a growth of good sized greenwood trees; and on sounding the depth of this bog with a boring rod, the rock beneath was found to present the shape of a cup, with the depth of twenty-five feet in the centre, so that including the rim, the depression would be about fifty feet deep, with the exception of a break down to the level of the bog on the east side. The nature of the rock, and the difficulty of accounting for the depression by any mode of wearing, gives to it in some degree the air of a small volcanic crater. But if it were such it must represent only the deeply seated base of the crater, as the evidence which is seen in the ice-grooves of the vicinity makes it probable the country has been much worn down by denuding agencies. In this vicinity some entangled beds of gneiss were met with, one of which was traced for upwards of a hundred yards running about N. 70° W. It was surrounded by the porphyritic rock.

From this porphyritic nucleus one or two porphyritic dykes were traced cutting the syenite for short distances, and some of a similar character were met with at such a distance as to make it probable that there are other porphyrytic nuclei. One of these dykes about seven yards wide, affording a beautiful example of the brownish-black and red variety, occurs on the south side of the road between the seventh and eighth ranges of Chatham, on the eighth lot. Its bearing, which was N. 85° W., would carry it to the south of the porphyritic mass described, from which the position in which the porphyry cuts the gneiss, is removed seven miles, though it is not more than one from the syenite, into which I was not so fortunate as to be able to trace it.

Another dyke of this aspect was seen in the ninth range near the line between the thirteenth and fourteenth lots, but in addition to the elements already mentioned it held disseminated grains of transparent colourless quartz. Its course appeared to be S. 54° W., and it intersected a porphyritic rock of the same colour and texture as the porphyry which was first described; which however like the dyke, contained grains of transparent quartz. Grains of this mineral were also observed in another porphyritic mass, whose course was N. 15° W., about a-quarter of a mile from the front of the twenty-fifth lot in the seventh range, and in the very front of the lot many loose fragments occurred, in which grains of transparent quartz and crystals of light flesh-red feldspar were imbedded in a compact feldspar base of a somewhat deeper flesh-red.

A porphyritic dyke was observed on the road between the sixth and seventh ranges on the twenty-third lot; with a reddish-grey finely granular base, it presented grains of quartz and crystals of flesh-red feldspar, some of them half an inch in diameter.

Of the tufaceo-porphyritic variety of rock, a lenticular mass crosses the seventh and eighth lots, close upon the rear of the fifth range of Grenville. It has a length of nearly half-a-mile, by a breadth of about 150 yards in the middle, and lies between the gneiss on the north and the syenite on the south. It has a bearing nearly west, with a turn-up a few degrees northward at the west end, and in this direction another and apparently an isolated mass was observed towards the front of the ninth lot of the sixth range, a short distance removed from the syenite, and wholly surrounded by the quartz rock and gneiss near the limestone.

In the vicinity of the pear-shaped porphyritic intrusion which was first described, there are met with two veins of a special character cutting the syenite, that deserve to be noticed. They consist of a white, yellowish-brown or flesh-red cellular chert, the colors in some cases running in bands parallel to one another, and sometimes being rather confusedly mingled, giving the aspect of a breccia. The cells are unequally distributed, some parts of the veins being nearly destitute of them,

while in other parts they are very abundant, and of various sizes, from that of a pin's head to an inch in diameter. On the walls of some of these cells or druses small transparent crystals of quartz are implanted, and in some there are the impressions of cubical forms, resulting probably from crystals of fluor-spar which have disappeared. On analysis, Mr. Hunt finds that the stone yields eight per cent. of soluble silica, and approaches in its composition to the nature of flint. From its cellular structure and other mineralogical characteristics, it belongs to the *silex meulière* of Brogniart, or what in England is called buhrstone.

One of these veins was observed in the north half of the first lot of the sixth range of Grenville belonging to Mr. John Stone. It was traced for about a hundred yards running in an east and west direction. It was difficult to determine its exact breadth, as it was not very well defined, and it appears to be less cellular than the other.

The second was traced in a nearly parallel course across the very front of the second lot of the sixth range, the property of a Mr. F. Kelly, from a position on Kingham Brook, and farther across the south half of the first lot, belonging to Mr. James Lowe, who was the first person to draw my attention to it as affording buhrstone. On his ground the vein has been more examined than elsewhere. It appears to run in a very straight line, of which the bearing is about east and west, and it stands in a vertical attitude, while its breadth varies from four to seven feet, being apparently however in one place nearly twenty. In the wider parts there are seen in the middle of the vein, masses six or eight inches thick of the syenite which constitutes the wall-rock. Where the vein is banded, the colors run parallel with the sides. The attitude and associations of the mass clearly show that it cannot be of sedimentary origin, and the soluble silica which it contains, with the volcanic character of the district, suggests the probability of its derivation from hot springs similar to the Geysers of Iceland. Waters holding silica in solution, have deposited this material upon the walls of crevices in the syenite, ultimately filling them up.

The intrusive rocks which have been described have a date anterior to the deposit of the fossiliferous formations. None of a similar character have been met with breaking through these formations, and the relations of the base of the Lower Silurian group along the foot of the hills composed of the syenite, are such as to make it evident that the fossiliferous beds in some places overlie worn-down parts of the volcanic rock. But all these intrusive masses are cut by a set of dykes whose relations to the fossiliferous strata are not so certain. These dykes are composed of a finely granular base, with an earthy fracture, consisting of feldspar and pyroxene, and having a dark brownish-grey color. In this base are imbedded rounded forms of black augite giving brilliant cleavage surfaces, and varying in size, from masses not bigger than a pin's head to some of several inches in diameter. These are associated with various sized nodules of calc-spar, filling cells that do not attain the diameter of the largest masses of augite, and with small spangles of mica, grey in fresh fractures, but weathering to a brass-yellow, on the surfaces of slightly weathered cracks and joints; small crystals of sphene were occasionally observed in the rock. In the nomenclature of D'Halloy the rock would be called a *melaphyre*, and it is the *augite-porphyry* of some German authors. By many geologists, from the accidental presence of the calc-spar nodules, it would be called an amygdaloidal trap.

One of these intrusive masses having a width of from three to ten feet was traced from the south half of the first lot of the sixth range of Grenville, not far from Mr. Lowe's buhrstone, where it cut the syenite, to the third and fourth lots of the same range, where it cuts the pear-shaped mass of porphyritic rock, thence across all the lots in succession to the eighth lot of the fifth range, where it cuts both the syenite and porphyry, and farther to the tenth lot of the same range, where it intersected the quartz rock and limestone. The whole distance is upwards of two miles and a-half, and the bearing N. 88° W.

Another was met with intersecting the limestone on the south half of the thirteenth lot of the same range. It appeared to be divided into several branches, two of which joining, the

united mass with a thickness varying from one to three feet, was followed across the limestone and the gneiss for upwards of half-a-mile, in the bearing S. 80° E. These dykes bear a striking resemblance to some of those which intersect the Lower Silurian group in the vicinity of the mountain of Montreal, and may be possibly of the same age; but none of them have yet been traced continuously from the Laurentian into the fossiliferous rocks.

The various exposures of crystalline limestone which have thus far been described, appear as has been stated, to belong to one and the same belt or group of calcareous strata. But in Chatham Gore, under a mile to the north of the exposures across the western lots of the third and fourth ranges, others were traced from the fifth lot of the fifth range of the Gore to the first lot of the fourth range of Wentworth. In a similar relative position exposures were observed on the banks and islands of the Great Lake of Wentworth, reaching from the northern extremity of the lake to the fifteenth lot of the first range, at the point separating the two southern bays, and back by the western side of the lake to the fourteenth lot on the line between the second and third ranges.

It appears probable that these exposures all belong to one band, which would run parallel to the one further south, with a great body of gneiss between; and from the form the southern band has been shown to present, the northern one would be above it. The whole distance, however, between the extremes of its yet known out-crop, seven miles, is not sufficient to justify any very positive assertion on the subject. The breadth of the belt does not in the parts observed appear to exceed from 120 to 220 yards.

Another calcareous area was partially examined in the rear of the seigniory of Mille Isles and the front of the township of Morin. In the seigniory the exposures extend from the fourteenth and fifteenth lots of the south range of the Saint Gabriel concession, the latter belonging to Mr. Constantineau, along the River Simon to the road into Morin, between the thirty-first and thirty-second lots. The breadth they occupy on the fourteenth and fifteenth lots is about 300 yards, which

appears to be maintained with considerable uniformity to the twenty-fifth lot; but here, by a southward bend in the south limit, it seems to widen to about three-quarters of a mile and again contracts on entering Morin.

Exposures of the rock are seen in Morin near Mallet's Mill on the Simon, which is on the thirtieth lot of the first range of the township. Others were observed in the first range to the eastward, in the rear of Mr. J. Saele's lot, which is the thirty-sixth, and towards the front of a lot supposed to be the fortieth, being a few lots to the N. E. of Mr. G. Hamilton's, which is the forty-third. Other exposures were found towards the rear of the second range on the forty-first lot, belonging to Mr. Baldwin, on the fortieth, and at Wilson's Mill on the thirty-ninth, as well as the next to the north-eastward, where its presence is indicated by a great circular sink-hole nearly an acre in superficies.

The course of the belt from Constantineau's, in Mille Isles, appears to be a little south of west, but about the line between the first and second ranges of Morin the belt appears to split into two, one set of exposures striking off to the south-westward. I have been informed that both branches extend into Wentworth, but what form is to be inferred from this will require further investigation. The extension of the exposures from the eastern extremity of the area in Mille Isles, though diligently searched for, was not discovered.

On the north side of this calcareous area there arises a mountain range of rock, the peculiar characteristic of which is, that in this and some other probably related localities it is chiefly composed of lime-feldspars, varying in composition between labradorite and andesine, and marked by the presence of hypersthene and ilmenite.

In the present locality the rock is chiefly labradorite, and consists of a fine grained paste of this mineral, of a purplish-grey, weathering to an opaque white, and holding cleavable forms of a lavender-blue feldspar, several inches in diameter. Many of these forms exhibit a fine golden-green and deep blue opalescence, and the same hues occasionally emanate from minute points in the paste. The rock is generally massive,

and it is occasionally very difficult to find any indication of those parallel planes which are so generally present in common gneiss. The large cleavable forms of labradorite, however, as well as the hypersthene and ilmenite, are found to prevail in belts that appear to be parallel to one another, and garnetiferous or micaceous bands occasionally indicate the same arrangement.

The limits of the rock characterised by the labradorite in this neighborhood have not yet been ascertained. It extends northward in Morin to the eighth range, a distance of eight miles, probably entering Beresford further on, and from the position where the north edge of the limestone meets the line between Morin and the seigniory of Mille Isles, it continues to the eastward across the north part of Abercrombie.

At St. Jerome a belt of the crystalline limestone was found to exist on the west side of the river; it was traced along its bank for a distance of a mile and a-half in a N. N. E. bearing, with a breadth of apparently about two hundred yards. The rock on the east side of it is composed to a large extent of lime-feldspar, but holding a considerable admixture of other minerals, it is not of so conspicuous a character, and does not so readily attract the eye.

The minerals have a reticulated arrangement, as in the case of the gneiss. Darker and lighter bands run parallel to one another, the shades being occasioned by the greater or less abundance of a fine-grained greenish lime-feldspar weathering opaque white, which occurs in spots surrounded by a darker coloured net-work, consisting of dark green pyroxene and magnetic iron ore, with small disseminated clusters of yellowish-red garnets. In this mass large and small individuals of labradorite, some of them two or three inches in diameter, are irregularly disseminated, and irregular veins or apparent segregations occur here and there, composed of flesh-red orthoclase and translucent colorless quartz.

On the west side of the river, rock of a similar character is met with, but there is seen also an interstratified mass of reddish hornblendic gneiss, the feldspar of which is an orthoclase. The breadth of the mass is 200 yards, and it is marked by

beds darker than other parts from the presence of more hornblende. Iron pyrites and molybdenite were observed in the rock, and it was cut by veins of pegmatite composed of a very pale flesh-red feldspar, weathering white, and translucent colourless quartz. Occasionally the pegmatite holds crystals of dark brown mica. One of the veins was large and very coarse grained, and they were all more or less characterised by the occurrence of schorl and what appeared to be small zircons. On the west side of this mass of gneiss smaller bands of a similar nature seemed to alternate with those containing lime-feldspar; beds of quartz were also interstratified, and some of these were in one place so loaded with small garnets, as to form a fine granular garnet-rock. The strike of the masses on each side of the limestone runs N. N. E. with it, and all dip to the westward at a high angle.

Lime-feldspar rock more resembling that of Morin in its opaque white massive aspect, was met with at New Glasgow, on the Achigan, in Terrebonne Seigniory; the stratification, however, was well marked by bands of garnets and pyroxene, and by alternations of the rock on the west side with common gneiss. The strike is a little to the eastward of north, with a dip to the westward, and the breadth observed was about three-quarters of a mile, without, however, the ascertainment of the eastern limit of the belt.

Similar rocks were observed by Mr. Hunt in Rawdon and Chertsey. In the former, a band of crystalline limestone of some importance runs in about the bearing of the north and south diagonal of the township, and somewhat east of it. Westward from this calcareous band, lime-feldspars were met with extending nearly as far as the west corner of Chertsey. Allowing this a strike parallel with the limestone, which was the strike generally observed, the western limit would run down to the New Glasgow exposures, and the breadth of the area characterized by the rock in this part would appear to be about twelve miles.

A large development of labradorite and andesine rock was also in 1852 observed on the Sault-à-la-Puce brook in Château-Richer, below Quebec. From a narrow calcareous belt about

two miles from the bank of the Saint Lawrence, its breadth extended northward to the rear of the settled parts on the brook, about four and a-half miles, and in its course to the eastward it was supposed to run north of Ste. Anne Mountain. This latter Laurentian mass appears to possess a character more approaching the common gneiss, as do also the precipices on the bank of the St. Lawrence at Cape Tourment.

The feldspars of Morin, Rawdon, Chertsey, and Château-Richer, with their associated ilmenite and hypersthene, are described at length by Mr. Hunt in his Report for 1855. The ilmenite is most abundant in the last mentioned locality; and it is not improbable that this mineral, still farther increasing in quantity to the eastward, may be found to culminate in the enormous mass described in a former Report as existing in St. Urbain at Bay St. Paul.

How these lime-feldspar rocks, and their associated limestones between Morin and Chateau-Richer, are related to one another has yet to be traced out; but it seems not improbable that they may all belong to one great undulating mass the whole way.

ECONOMIC MATERIALS.

Most of the economic minerals existing in the district of which the physical structure has thus been partially examined, have been described or alluded to in former Reports; one or two, however, have now been met with for the first time in Canada, and in respect to others a few additional localities require to be mentioned.

Magnetic Oxyd of Iron.—Of this ore of iron the only new locality which came under my observation, bearing an aspect of some importance, was on the south half of the third lot of the fifth range of Grenville, the property of Mr. Thomas Loughran. The bed was from six to eight yards in breadth, and it was traced running westward and then turning south-west, the whole distance being about 150 yards. The rock on each side of it appears to be a micaceous gneiss interstratified with many bands of quartzite. The iron ore and the strata

run parallel with one another. The syenite flanks the gneiss a little distance on the north and cuts the stratification to the east and the west, leaving only about 350 yards of the gneiss on the strike. The bed of iron ore is of course cut off by the syenite in the same way, and the greatest extent of the bed can scarcely exceed the measure just given to the gneiss. The iron ore is somewhat mixed with the earthy minerals of the gneiss, but not so much as to reduce its produce in iron below a fair workable per centage. The specimens brought away from the bed and analysed by Mr. Hunt give 52·23 per cent. of pure metallic iron.

On the north half of the same numbered lot in the fourth range, belonging to Mr. Frazer, there are less important indications of the same description of ore. The bed did not appear to be over a few inches in breadth, and the largest lumps which had been obtained did not exceed a foot thick. The ore was traceable for about a hundred yards, by surface indications, from the same syenite interrupting the gneiss on the west side in the previous locality, and the bearing was across the lot about parallel with the other band; but the syenite on the west and on the east diverging from one another going southward, there would probably be a greater length of the smaller band on the strike than that given to the larger.

Indications of magnetic iron ore were pointed out to me also on the fifth lot of the eighth range, on the rear of that part of it which belongs to Mr. D. Kemble, which I believe is the south half. The rock is gneiss, and in it about an inch of the ore runs in a straggling manner with the strike of the rock. Indications are also met with on the fourth lot of the seventh range, belonging to Mr. Cousins. None of the specimens from this position shewn me presented a thickness over an inch, and none were reported over three inches, and though beds of such dimensions would not be workable, these two are worthy of remark, from the fact that striking toward one another they may probably belong to one and the same band, the place of which would be about a mile from the outside of the limestone trough, of which the range has been traced through the township.

The more important ore bed in the fifth range, though on the opposite side of the syenite, is in the strike of those more to the north, and though twice as far removed from the limestone, that may arise from the influence of the fold which carries the limestone more to the westward in the fifth range, to the turn produced by which, the westward strike of the ore at Loughran's may be conforming.

The intrusive syenite, breaking the continuity of the beds, makes it difficult to speculate on the point, but it is one to be kept in view, as should the ore in the three localities belong to one band, the fact that it becomes of a workable thickness in one of them, affords a ground to hope that it may become so in others, while the relation of the band to the limestone, which has been traced about eighty miles through the country, would greatly extend the area in which it might reasonably be expected to be found, and in some measure guide the direction in which a search for it should be made. The small ore seam on Mr. Frazer's land would be a parallel one, still further removed from the limestone, but like the other it might perhaps in some parts of its distribution become larger.

Sulphuret of Molybdenum.—Molybdenum is a rare metal, which, in some of its combinations, is found to be a useful chemical re-agent, and has been recently employed as a blue dye for silk and cotton. The value of the sulphuret, which is one of its ores, is about fifteen shillings the pound, but the commerce in it is of a very limited nature. As has already been stated, a specimen of the sulphuret was met with in the flesh-red gneiss on the west side of the band of crystalline limestone at Saint Jerome, and though the quantity was no more than a mere trace, it is here noticed, as it is the fourth instance of its occurrence in Canada, and the ore is to be kept in mind as one of the substances which may be hoped for in larger abundance.

The first locality of its occurrence was in a vein in granite, on the west side of Terrace Cove, Lake Superior; the second, that mentioned by Mr. Murray in his Report of 1852, on the west side of Mud-turtle Lake, north of Balsam Lake; specimens from a third locality were sent me from the River Doré,

near Grôs Cap, above Michipicoten, on Lake Superior. The locality mentioned by Mr. Murray, like the one at St. Jerome, occurs in the Laurentian series of rocks.

Plumbago.—Two localities of plumbago occuring in the area which is the subject of the present Report, have been mentioned on a previous occasion by Mr. Hunt and myself, as met with in the tenth lot of the fifth range of Grenville. To these may now be added one on the north half of the second lot of the tenth range of Grenville, belonging to Mr Dolan, where the mineral occurs in a vein; and another on the fifth lot of the fourth range of Chatham Gore, where considerable lumps of it, strewed over the surface in the vicinity of the crystalline limestone, appear to indicate the chance of a workable quantity. The plumbago associated with the Laurentian limestones is of a gray colour and foliated structure, resembling that of Ceylon; its price would not exceed from £3 to £5 the ton when clean.

Mica.—The cleavable character of mica, its transparency, its elasticity and refractory nature, render it valuable for several purposes, the more important of which relate to it as a substitute for glass for ship windows, and in some countries for house windows, for stove fronts, and such like applications. For the last purpose it is greatly used in North America. The prices at which plates of five by seven inches sell in Montreal, is about five shillings the pound.

Mica occurs in great abundance in small scales in the crystalline limestones of the Laurentian series, but sometimes also in cleavable crystals sufficiently large to be economically available. When these are met with they are generally near the quartzite or gneiss limiting the limestone, or near some interstratified mass of similar character, and they are associated with an aggregate of other minerals; among them, in addition to feldspar, are tabular-spar, pyroxene, apatite, sphene, iron pyrites, idocrase, garnet, tourmaline, zircon, and sometimes, corundum.

The locality in which the largest crystals of the mica were met with was the ninth lot of the sixth range of Grenville, belonging at the time of my visit to Mr. Inly, who subse-

quently mined and prepared the mica for sale in small quantities. One of the crystals was sufficiently large to enable Mr. Inly to send to the Paris Exhibition a sheet measuring two feet by fourteen inches.

Another locality in the same neighborhood which shewed crystals of good promise was the tenth lot of the fith range, belonging to Mr. Johnstone, and another was on the land of Mr. Burns, which is the first lot of the tenth range.

Buhrstone.—In the geological description of the intrusive rocks, mention has already been made of a vein of buhrstone occurring on the first lot of the sixth range of Grenville, the property of Mr. Lowe, and it has been stated that the vein is from four to twenty feet wide, and cuts a mass of syenite, in which its attitude is vertical, whilst its course is about east and west.

By the French mineralogists the general name of *silex* is given to all those compact uncrystallized forms of quartz, which, among English authors, are designated by the various names of flint, chert and hornstone, which, though differing slightly from one another, have a general aspect in common; and if any of these are of such a porous character as to yield a material fit for grinding grain, they would be termed *silex meulière* by the French and buhrstone by the English. The best three varities of millstones exhibited in Paris in 1855, and probably the best that are known, are the grey stones of Andernach in Prussia, which are made from a porous feldspathic lava, and are not buhrstone; the stones of Namur in Belgium, which are manufactured from a fossiliferous chert of the carboniferous epoch, in which the cells arise from the moulds left by organic remains that have been dissolved out; and those of La-Ferté-sous-Jouarre, in France, preferred to all others, which are made from a *silex meulière* approaching to opal in its nature, and derived from deposits of the tertiary age. In this stone the cells are irregular and numerous, and do not owe their origin to fossils.

The Grenville stone in its mineral character is most like that of Namur, being a flint or chert, while in its cells it resembles that of La-Ferté. These cells, however, are not very equally

distributed, and some parts of the vein are much more sòlid, and therefore not so good as others.

Until practical experiments have been made to try this material, it cannot be asserted with confidence how the stone would compare with either the Belgian or French, but it appears probable that enough of it could be procured to yield a large supply of good millstones, if the expense of working it should not prove too great.

To quarry it effectually it would be necessary to blast away the syenite, which is not a soft rock, from one side, in order to make room for forcing the stone away, by means of wedges, from the wall on the other; and it is almost certain that it would be necessary, as in the case of the French buhr in forming millstones, to build them up of pieces fitted together and secured by means of an iron hoop.

Garnet-rock.—Garnet possesses a hardness between that of crystalline quartz or rock crystal and topaz. When reduced to a powder it is therefore a better material than sharp silicious sand for the purpose of giving a smooth surface to metal and stone work preparatory to polishing, and for cutting gems, and though inferior to emery in hardness, is occasionally used as a substitute for it.

On the west side of the crystalline limestone at Saint Jerome, beds of garnet-rock are interstratified among the quartzite of the locality. They vary in their composition, and sometimes consist of a number of hyacinth-red garnets weathering pink, with yellowish-white prisms of diopside, among which are present small grains of greenish feldspar weathering opaque white, a few minute scales of graphite, and still fewer and more minute brilliant black grains, supposed to be schorl.

In some layers the garnets almost exclude the other minerals, but many variations occur in the proportions in which they are disseminated, in parallel undulating bands, in the thickness of the four or five feet composing the escarpment in which they are exposed, the bands being separated by thin divisions of quartzite and feldspar. On the whole the garnets greatly prevail, and would appear to be in sufficient quantity for economic application.

A similar rock was observed by Mr. Hunt on the twentieth lot of the seventh range of Rawdon, belonging to Mr. Corcoran, where on the west side of the band of crystalline limestone which runs through the township, there is a great exposure of quartzose and quartzo-feldspathic rock, all more or less mixed with garnet. In one part of this there is a bed of massive garnet-rock nearly pure, with the exception of a few scales of black mica and grains of schorl. There run through the bed, a few thin layers of quartz rock, which enclose rounded dodecahedrons of garnet about the size of peas; but the whole mass, which is about three feet thick, would yield a great abundance of garnet for economic purposes.

Rensselaerite.—This mineral is a hydrous silicate of magnesia very much resembling soapstone to the touch and to the eye, as well as in its refractory nature; it is, however, compact or sub-granular instead of foliated, and not so soft as soapstone, its hardness being about that of calc-spar. It differs also from soapstone in containing a somewhat less proportion of silica.

Professor Emmons, of the New York Geological Survey, who was the first to distinguish its mineralogical characteristics and give it a specific name, describes it as economically applicable to all the purposes for which soapstone is used, and several others besides. Being of a tougher nature, and not liable to exfoliate, it is more durable; receiving a higher polish, it is capable of greater embellishment; and it can be readily sawn and carved into furnace linings, ingot moulds, chimney pieces, inkstands, tables and a multitude of other useful forms. According to Professor Emmons, its color varies from greenish-white to brownish-black, and it occurs in rock masses.

A mass of this silicate of magnesia of a greenish-white color, was met with on the thirteenth lot of the fifth range of Grenville, and appeared to run into the same numbered lot on the sixth range, the property of Mr. Cowie. Only the edge of the bed was seen, where it occupied a place between the gneiss and the crystalline limestone there exposed. It appeared, however, to extend under the soil sufficiently far to authorize the expectation of a workable quantity of the mineral.

With it was associated on Mr. Cowie's land a hydrous

silicate of magnesia very much resembling *aphrodite* in its characteristics, or the meerschaum of Longbanshyttan, in Sweden. The Canadian mineral is a cream-white, unctuous, compact earthy looking substance, polishing under the knife, and strongly adhering to the tongue. It is heavier and harder than the meerschaum of Natolia. Its hardness is rather lower than that of rensselaerite. and it can readily be carved into the bowls of tobacco pipes, for the manufacture of which it would form an excellent material.

Syenite.—The syenite which is largely spread in Grenville and Chatham would afford an inexhaustible amount of excellent durable building stone, though it would, perhaps for the present be in this country, where limestone is so largely used, too expensive to work. In consequence of the color of the feldspar, which is an orthoclase, the blocks obtained in Chatham from the eastern side of the mass would be a greenish-white, while those from the western side, in Grenville, would be some tinge of flesh-red, deep or pale. The rock in some places is divided by parallel joints, which would greatly facilitate the operation of quarrying it for the sizes of stones applicable to the construction of dwelling houses, but perhaps weaken it for the very large blocks required for use in public works. The parallel joints are at right angles to one another only in two planes, and the stones would require dressing on the third, to reduce them to the forms of cubes and rectangular prisms. In some parts, however, where the natural planes of division are far apart, blocks suited for any purpose of construction may be obtained, and the stone splits with much regularity in any direction required by the aid of wedges.

A beautiful variety of the rock is obtained in the south half of the second lot of the fifth range of Grenville. The feldspar is deep flesh-red and the hornblende black, and the stone, which is capable of a high polish, appears to me to give as fine a material as the red granite of Aberdeen.

Porphyry.—It has already been said in the geological part of the Report, that the porphyries which intersect the syenite would, in several parts, yield a material of a superior character

for ornamental purposes. Some of them present a striking and harmonious contrast of colours, particularly those in which deep flesh-red well defined crystals of feldspar are set in a dark grey, blackish-brown, or velvet-black ground. The texture of the stone renders it capable of receiving a brilliant polish, and for all the objects to which materials of this description are applied in the arts, few porphyries, in my opinion, would surpass it. The best example of this porphyry, being that in which the crystals of feldspar are the largest and most pronounced, occurred, as has already been stated, on the eighth lot of the seventh range of Chatham.

The green variety, to which also allusion was made, occurs on the east side, in about the mid-length of the fourth lot of the sixth range of Grenville. It is still more compact, and has a more conchoidal fracture than the black and red, and it would probably take as fine a polish as the best jasper, to which it is about equal in hardness. The color is a leek-green, passing into a blackish-green, and it is marked with small red, brown, and black spots, from the presence of some crystals of feldspar and many minute accidental grains and fragments of foreign rock. There appeared to be a width of about seventeen yards of the greenish colored rock, running in a course N. 70° W., crossing which northward, the green gradually passed into a brown, intermediate between olive and chocolate-brown, while the rock preserved its hardness, compactness, and other characteristics for about 150 yards.

Labradorite.—The great beauty of the opalescent varieties of labradorite, which are used in jewellery, is too well known to require mention. They occur as cleavable masses enclosed in a finer grained paste of the same mineral character, constituting great mountain ranges of rock, and when they are thickly disseminated in the paste, the stone would become an unrivalled decorative material, applicable to architectural embellishment and articles of furniture. Its hardness is about that of ordinary feldspar; it would, in conseqence, be more expensive to cut and polish than serpentine or marble, but it would not be so readily scratched or broken, and would, therefore, prove more lasting. Professor Emmons states that a

block of the stone, submitted experimentally to the action of a common saw (such, I presume, as is used in sawing marble), attached to the waste power of a mill, was cut to the depth of two inches in a day, which I understand to be about one-fifth the progress that would be made in a block of good marble, in the same time, by the same means. It would thus appear that though the operation is slower in the case of labradorite, there is no greater amount of mechanical contrivance required in regard to it, and that slabs could be prepared for chimney-pieces, pier-tables, and other articles of furniture, at a cost beyond that of marble not greater than is proportionate to the superior beauty and durability of the material.

The locality in which the best opalescent specimens were observed, *in situ*, was at Cap Mahue, in the tenth range of Abercrombie. Here the rock is composed of a lavender-blue fine-grained labradorite, which includes cleavable opalescent forms of various sizes, up to ten inches in diameter, giving a play of colors, which, in some instances, is a golden-green, in others, a bronze-green, and occasionally an ultra-marine-blue. Exteriorly the rock weathers to an opaque greyish-white. It is massive, but the quarrying of it would be assisted by three sets of parallel joints, two of which give the precipices a sub-columnar aspect. The underlie of one set of the joints is N. $<80^\circ$ to 90°; of another, W. $<80^\circ$ to 86°; and of the third, S. $<7^\circ$. The rock occasionally holds garnets in some abundance, and these appear to run in layers, with a dip northward. There are a few patches of quartz-rock, which run parallel with the garnets.

Boulders, holding opalescent masses, are met with in abundance in the neighbourbood of Grenville, and several large fragments of one of these having been forwarded to Montreal, for the Paris Exhibition, by Messrs. Sykes, de Bergue & Co., I took the opportunity of placing one of the specimens in the hands of Mr G. Hermann, of Paris, who has a large establishment for working into ornamental forms all the harder species of rock, and he has sent to me a small vase made from it. The color of the stone, in fresh factures,

before being worked, appeared to be a lavender-grey, but the polished surface of the vase presents a general blackish-green ground, with purple and grey spots, as well as opalescent portions, reflecting, when in a proper position, an ultra-marine-blue. The high polish and beautiful colors render this vase a very ornamental object.

A block of the jasper conglomerate of the Huronian series, sent to me by the Hon. W. B. Robinson, from the Bruce mines, was likewise placed in Mr Hermann's hands. The vase wrought from it, with its whitish quartz ground, and blood-red jasper pebbles, has a very striking and beautiful effect.

Limestone and Lime-feldspars.—The crystalline limestones of the Laurentian series are quite as good for all the economic purposes to which carbonate of lime is applied, as the earthy limestones of the fossiliferous formations. It is from the latter, however, that is obtained nine-tenths of the material used throughout the country, for the very good reason that more than nine-tenths of the works of construction, both public and private, are raised upon the fossiliferous rocks, and for such present works, these rocks therefore afford the nearest sources of supply. Thus the inhabitants are well acquainted with the aspect of the fossiliferous limestones, and can easily recognise them, but very few of them understand the nature of the highly crystalline calcareous beds of the Laurentian series. Hence it is that settlers in the back townships, who have dwelt many years upon these rocks, have been accustomed, when in want of lime for the manufacture of potash, or the construction of their chimneys, to send to the fossiliferous deposits for it—the distance being sometimes thirty miles—when it might have been obtained at their own doors. In following out the calcareous bands of the gneiss district, in 1853, therefore, especial pains were taken to point out their character to the settlers, wherever exposures were met with; and in visiting some of the same localities last season, I had the satisfaction of finding lime-kilns erected, and lime burnt in four of them.

The fossiliferous rocks, in a large part of Canada, maintain-

ing an attitude approaching horizontality, give a much more even surface than the corrugated series coming from beneath them, and this, combined with a generally good soil, renders them more favourable for agricultural purposes. It is over them, too, that the River St Lawrence maintains its course, affording an unrivalled means of exit for the produce of the land, and of entrance for the materials that are to be received in exchange. It is only a natural result of these conditions that the area supported by the fossiliferous rocks should be the first settled. This area, however, constitutes only between 60,000 and 80,000 square miles, while the whole superficies of Canada comprehends 330,000 square miles, or about five times the amount.

Four-fifths of Canada thus stand upon the lower unfossiliferous rocks, and it becomes a question of some importance, before it has been extensively tested by agricultural experiments, to know what support this large area may offer to an agricultural population. An undulating surface, derived from the contorted condition of the strata on which it rests, will more or less prevail over the whole of this region; but the quality of its soil will depend on the character of the rocks from which it is derived.

These rocks, as a whole, have very generally been called granite, by those travellers who with little more than casual observation have described them, without reference to geological considerations. The ruins of granite are known to constitute an indifferent soil from their deficiency in lime, and hence an unfavourable impression is produced in respect to the agricultural capabilities of any extended area, when it is called granitic. Such soils are however never wanting in those essential elements the alkalies, which are abundant in the feldspars of the granite.

In the Reports of the Survey, the Laurentian rocks have been described in general terms as gneiss, interstratified with important masses of crystalline limestone. The term gneiss, strictly defined, signifies a granite with its elements, quartz, feldspar and mica, arranged in parallel planes, and containing a larger amount of mica than ordinary granite possesses, giving

to the rock a schistose or lamellar structure. When hornblende instead of mica is associated with quartz and feldspar, the rock is termed syenite, but as there is no distinct specific single name for a rock containing these elements in a lamellar arrangement, it receives the appellation of syenitic gneiss.

Gneiss rock then becomes divided into two kinds, granitic and syenitic gneiss, and the word gneiss would thus appear rather to indicate the lamellar arrangement than the mineral composition. Granitic and syenitic gneiss were the terms applied to these rocks in the first Reports; but as granite and syenite are considered rocks of igneous origin, and the epithets derived from them might be supposed to have a theoretical reference to such an origin of the gneiss, while at the same time it appears to me that the Laurentian series are altered sedimentary rocks, the epithets, micaceous and hornblendic have been given to the gneiss, in later Reports, as the best mode of designating the facts of mineral composition, and lamellar arrangement, without any reference whatver to the supposed origin of the rocks. When the general term gneiss therefore is used, it may signify both kinds, or either; and the epithets micaceous and hornblendic are applied to the rock to indicate that the mica greatly preponderates or excludes the hornblende, or the hornblende the mica.

In no part of the area included in this Report is hornblende completely absent from the gneiss, and sometimes it predominates over the mica; hornblende contains from ten to fifteen per cent of lime, so that the ruins of the rocks of the area, such as they have been described, whether gneiss, greenstone, syenite, or porphyry, would never give a soil wholly destitute of lime. Of this necessary ingredient, the lime-feldspars would be a more abundant source. Different species of them from andesine to anorthite, may contain from about five up to twenty per cent. of lime, and the range of those Canadian varieties which have been analyzed by Mr. Hunt, is from seven to about fifteen per cent. The personal exploration which is the subject of the present Report, has shewn, for the first time, that these lime feldspars occur in this province, and probably in other regions, in mountain ranges, belonging

to a stratified deposit, and not in disseminated or intrusive masses. The breadth of these displayed in the district examined, demonstrates their importance; and the fact that the opalescent variety of labradorite was ascertained by Dr. Bigsby to exist, *in situ*, on an island on the east coast of Lake Huron, while the name of the mineral reminds us of its existence at the eastern extremity of the Province, sufficiently points out that the lineal range of the lime-feldspars will be co-extensive with Canada. We may therefore anticipate a beneficial result from their influence upon the soils, over the whole breadth of the province.

The ruins of the crystalline limestone constitute a most fruitful soil, so much so that the lots first cleared in any settled area of the Laurentian country, usually coincide with its range. In these limestones phosphate of lime is sometimes present in great abundance, and there is scarcely ever any large exposure of them examined, in which small crystals of the phosphate are not discernable by the naked eye. Mica and iron pyrites, are present, to furnish other essential ingredients, and the easily disintegrating character of the rock readily permits its reduction to a soil. The effects of these limestones and lime-feldspars are not however confined to the immediate localities in which the beds are found, for boulders of them are met with transported to southern parts, even far on the fossiliferous rocks beyond; and there can be little doubt that their fragments are very generally mixed with the soils of the Laurentian country. Thus while the diversity of minerals in the different rocks of the series furnishes the ingredients required to constitute good soils, the agency of the drift has mingled them, and considering the resistance to disintegration offered by most of the rocks, with the exception of the limestone, the deficiencies that may exist will rather be in the quantity of soil covering the rocks in elevated parts, than in its quality where the materials have been accumulated.

Peat.—The only addition I have to make to the economic materials is peat, of which four deposits were met with in the course of my examinations; one of these forms a belt of about four acres in width, across the middle of the fourth and fifth lots

of the fifth range of Grenville. The area of the bog is about thirty-six acres, and its depth ten feet. Mr. Loughran, a settler in the neighbourhood, who understands the use of peat, has tried its quality, and pronounces it to be excellent.

There is a similar deposit on the north half of the first lot of the same range, with an area of about the same extent; a pole has been driven down into it, to the depth of about fifteen feet. Another peat bog exists on the fourth lot of the seventh range, belonging to Mr. R. Cousins. It trenches a little upon the fifth lot, and may contain altogether about thirty acres. A fourth deposit was seen in a tamarack swamp, extending over about forty acres of the fourth and fifth lots of the first range of Harrington. The depth tried in several places varied from ten to twenty-five feet. There would be no great difficulty in draining all the areas which have been mentioned.

GEOLOGICAL MAP AND REPORT.

A sum of money having been voted by the legislature, among the contingencies of 1854, for the publication of a Geological Map of Canada, exhibiting the facts that had been ascertained by the Survey up to that time, I had hoped to make available for the purpose a map which I had caused to be prepared for the Paris Exhibition. The topography of this map was a reduction by pantagraph to a scale of twenty-five miles to the inch, from various maps in general use in the province.

The short time given for the preparation of the Canadian contribution to the Paris Exhibition, and the duties assigned me in respect to the minerals, necessarily made the map a hasty production; but desirous of rendering my sojourn in Paris available for its speedy publication, I ventured to place it in the hands of Mr. Dufour, one of the first map engravers of the French metropolis, recommended to me by Mr. Hector Bossange, who, with Mr. De Puibusque, Mr. R. F. Maitland, and Mr. W. Bolton, as honorary commissioners, resident in Paris, by their taste and their knowledge of business, afforded most essential service, both before and after the arrival of the special commissioners, in securing the success which attended the Canadian part of the Exhibition.

It was not until some progress had been made in the engraving, and after my return to Canada, that a more leisurely comparison of the topography with original surveys, made me aware of several distortions in it, produced by the difficulty of reconciling the discrepancies of different surveyors and publishers, who are considered authorities. In consequence of these distortions it appeared to me expedient to abandon the map and undertake the construction of another from original documents, in which labour considerable progress has now been made.

From the geographical position of Canada, it is scarcely possible to represent the topography of the province without including that of several of the sister colonies, and a considerable portion of the United States. This is of advantage to a map of Canada, in making her commercial relations understood, while it is almost indispensable to a clear appreciation of her geological structure, that the geology of a portion of the surrounding countries should be given at the same time. It was in endeavouring to unite the topography of some of these surrounding portions to the delineation of Canada, that the chief difficulties occurred.

Guided by Bayfield's surveys, most of the published maps represent with considerable accuracy the geographical relations of those parts of Canada east of Detroit, but errors creep in when an attempt is made to superadd the delineation of Lake Michigan. This is not surprising when the differences between authorities are considered.

Thus, for example, Farmer's map of Michigan, for 1844, (the one to which I had recourse) appeared to be a most elaborate representation of all the townships and measured lines that could be obtained from the most authentic sources, and while it agreed nearly with Bayfield at Detroit, it shewed the longitude of Chicago to be 88° 23′ W. from Greenwich. Colton's map for 1853, which was recommended by scientific men for general accuracy, also nearly agrees with Bayfield at Detroit, but shews the longitude of Chicago as 87° 28′ W., making a difference of about 55′. There was thus between Farmer's and Colton's maps, both of which were entitled to

respect, a discrepancy of upwards of forty-seven miles in the position of an important commercial city, and with it of the whole of Lake Michigan. A recent edition of Farmer's map, that of 1856, now published by Colton, of course obviates the difference.

Belcher's map of the province of Nova Scotia, compiled from actual and recent surveys, under the authority of the provincial legislature, by W. Mackay, in 1834, and corrected to 1855, gives the longitude of Cape Chignecto, a most prominent point in the Bay of Fundy, as 64° 57′ 50″ W., while a chart of the coast of North America, constructed and drawn by J. S. Hobbs, F.R.G.S., hydrographer, in 1848, gives it as 64° 36′ 30″ W. The difference is 21′ 20″, or seventeen and a-quarter British miles. Hobbs' chart is used by navigators; so also is a chart, published by J. Embray & Sons, in London, in 1853, said to be compiled from surveys made under the authority of the Admiralty; in this the longitude of Cape Chignecto is the same as that given by Hobbs.

Another chart guiding navigators, published by E. & W. Blunt, New York, in 1853, compiled from the surveys of the United States Coast Survey, and surveys under the British Admiralty, gives about the same longitude to Cape Chignecto as Mackay, and a general sketch, on a small scale, of the coast of the Bay of Fundy, which appears in the reports of the United States Coast Survey, for 1855, coincides with it.

With such discrepancies among the best authorities in regard to neighboring parts of both extremities of the province, and many others in intermediate positions, it is very obvious that much enquiry and correspondence have become necessary to arrive at even proximate results.

The most effective means now employed to determine the relative longitudes of places is the electric telegraph, and it has been extensively resorted to by the eminently scientific men directing the Coast Survey of the United States. All the positions ascertained by it are reduced to the standard of Cambridge Observatory, near Boston, which is supposed to be the position most accurately compared, in various ways, with Greenwich Observatory, in England;

and no doubt it will remain so until the Atlantic wire is established. By means of the electric wire, Admiral Bayfield has ascertained the astronomical place of Halifax Dockyard Observatory in relation to Cambridge, and having, by this means, proved the general correction to be applied to the longitudes in his survey of the Gulf and River St. Lawrence, he has been so obliging as to transmit to me a list of corrected observations over the field of his labours, that can be relied on.

Dr. Toldervy, and Professor Jack, of King's College, Fredericton, have compared the position of their observatory with that of Cambridge, and subsequently with several places on the river St. John. Professor Jack has kindly furnished me with a list of these, and with a considerable number of places otherwise astronomically determined. Lieutenant Ashe, of the Quebec Observatory, with the aid of Professor Jack, has fixed the relation of Quebec with Fredericton; and he is now, with the obliging assistance of Professor Bond, director of the Cambridge Observatory, making a direct comparison between Cambridge and Quebec, which will farther confirm the result obtained through Fredericton.

In compliance with the clause in the Geological Survey Act, which assigns to me the duty of ascertaining the longitudes and latitudes of important places, I have availed myself of the services of Lieutenant Ashe, to compare Toronto, Kingston, and Montreal with Quebec; and before placing the map, which is in progress, in the engraver's hands, I am desirous of the further aid of Lieutenant Ashe, in determining the positions of Windsor, Collingwood, and Ottawa, a task which, with the energy and perseverance which he possesses, there is no doubt he will accomplish in time. I am in hopes also, that, with the obliging aid of Lieutenant-Colonel Graham, Topographical Engineer, U. S. A., stationed at Chicago, he will have an opportunity of exchanging signals between Quebec and Chicago.

The electric wire, of which Lieutenant Ashe has availed himself in his operations, is that of the Montreal Telegraph Company; and I have to render my thanks to the president and directors of the company, as well as to their superinten-

dent, Mr. Wood and his assistants, for the use of the wire, and the ready zeal with which they have aided us on all occasions. At the Toronto Observatory, Lieutenant Ashe was kindly assisted by the director, Mr. Kingston. The managers of the Kingston Observatory were so obliging as to place it at the disposal of Lieutenant Ashe; and, at Montreal, the Corporation of the city, with the most ready complaisance, assigned to us a small unoccupied building, considered eligible as a temporary observatory. A first trial was made in Montreal, from the top of the Exchange building, with the kind permission of the chairman of the company to whom it belongs, but a tremulous motion, which appears unavoidable in all positions where the transit instrument is not placed on a solid mass of stone, destroyed the value of the observations.

Modified by the results of the electric observations to which allusion has been made, the documents which will serve to give the topographical details required for the map are the surveys of the lakes, river and gulf of Saint Lawrence, by Bayfield and others under the Admiralty; the maps of the north and north-western lakes, by Col. James Kearney, Topographical Engineer, U. S. A.; the maps and reports of the U. S. Coast Survey; the map of Canada, by Mr. J. Bouchette, of the Crown Land Department; Colton's Maps of the United States, recommended for their accuracy by the officers of the U. S. Coast Survey; together with various district maps of Upper Canada, compiled and published by different surveyors and authors. I hope also to be able to make available, in bringing townships together in their true relations, the plans of railroads, which the Geological Survey is entitled to call for under the legislative enactment making provision for its continuation.

A map of the seigniories and townships of Lower Canada having been compiled, by order of the Government, by Mr. Wells, on the scale of two miles to an inch, I trust I shall be permitted, notwithstanding the map is not yet published, to glean from it such corrections as it may suggest. Mr. Devine, draughtsman in the Crown Land office, has for some time been engaged in compiling a map of western Canada on the scale of four miles to an inch, while Mr. J. Bouchette has prepared

one of the eastern division on the scale of six miles to an inch. The known zeal of both these gentlemen to improve Canadian topography has induced me on all occasions, and with the greatest pleasure, freely to contribute to their work all the unpublished geographical details that have been ascertained on the Geological Survey; and I am prepared to believe they will be most ready to return the favor by preventing me from promulgating errors, if a reference to the details of their respective maps can obviate them. The geological map will be on a scale so much smaller than theirs, and its whole object so completely different, that it can in no way interfere with the purposes for which theirs are intended.

The geology of those parts of the map which are out of Canada will be derived from original sources. The geological details of New Brunswick will be contributed by Professor Robb, of King's College, Fredericton; those of Nova Scotia by Professor Dawson, of McGill College, Montreal; those of Newfoundland will be derived from Mr. Jukes, who was employed by the government of this island to survey it, and who now directs the Geological Survey of Ireland, as well as from the geological papers of Admiral Bayfield; such parts of the United States as may be required will be contributed by Professor Hall, State Geologist of New York.

The style of the map is intended to be similar to that published in Paris to represent Canadian Geology at the Exhibition, and will be executed by the same hands. The style of this map was so pleasing to the Geological Society of France that the president, Mr. Elie de Beaumont, requested permission to introduce an edition of it into the published Bulletin of their proceedings.

I have the honor to be

Your Excellency's most obedient servant,

W. E. LOGAN.

REPORT

FOR THE YEAR 1853,

OF

ALEXANDER MURRAY, Esq., ASSISTANT PROVINCIAL GEOLOGIST,

ADDRESSED TO

WM. E. LOGAN, Esq., PROVINCIAL GEOLOGIST.

MONTREAL, 1st February, 1854.

SIR,

In the spring of the year 1853, you were pleased to direct me to make an examination of a portion of the unsurveyed region lying between Georgian Bay, in Lake Huron, and the Ottawa River. In this I was engaged the whole summer and autumn following, and I have now the honour of laying before you a Report of the progress then made.

The line of route I had laid down as best calculated to afford general information, promising to be a very long one, and little or nothing being known to me of the character of the country through which I should have to pass, I deemed it prudent to supply myself with a more complete stock of provisions than has usually been required, and to take with me an extra canoe and two additional hands for its navigation, for the first month of our voyage; by the end of that time I was in hopes we should be far enough advanced, and sufficiently lightened, to dismiss the extra canoe, and reach some settled part with the usual complement of four men and two canoes.

Not being acquainted with any accurate survey of the portion of the interior I was about to visit, the main water courses naturally offered the greatest facilities for my work, as it appeared to me that by following some one of the main streams which fall into lake Huron to its source, I might be able to cross the water-shed, and find my way to the Ottawa by one of the rivers falling in the opposite direction. The river selected is a large stream known as the Muskoka; the course of this was followed to its head, beyond which a short portage brought us to the source of the Petewahweh, and by its channel we descended to the Ottawa. Returning we ascended the Bonne-chère River to a sheet of water well known to the Ottawa lumberers as Round Lake, from which we crossed to another expansion, likewise well known as Lake Kamaniskiak, on the main branch of the Madawaska. We descended the Madawaska to the York or South-West Branch, known as the Shawashkong or Mishawashkong (the river of marshes); pursuing its upward course to the head, we again crossed the height of land and finally came out on Balsam Lake by the channel of the Gull River.

With the exception of the portion of country travelled between the water-shed and Balsam Lake, the line of route was carefully measured by the micrometer telescope, and the courses taken by the prismatic compass; and being supplied with an excellent repeating circle, by Troughton and Simms, and a reflecting horizon, I was enabled to check my measurements by frequently ascertaining the latitude, by observations of the sun or moon. By the aid of a good theodolite I was likewise enabled to ascertain the heights of the principal falls and rapids, and thereby to acquire a fair approximative knowledge of the relative heights of the rivers and lakes, and of the hills or mountains surrounding them, over the level of the sea. The variation of the compass was likewise taken on all convenient occasions by azimuths of the sun.

GEOGRAPHICAL DESCRIPTION.

The Muskoka River.

The Muskoka River falls into Georgian Bay by at least two and probably more outlets; we ascended the most southern of these, commencing where it joins the waters of Lake Huron at the north-east angle of Kennie's Bay, in latitude 44° 57′ N., longitude 79° 53′ W. The ascent of the river from this point takes a general course due north for a distance of from five to six miles, where one of the outlets branches off, and then turning abruptly to the eastward, maintains an easterly direction for about thirteen miles to the exit of Muskoka Lake. This is an extensive sheet of water studded with numerous islands, and bounded by a very irregularly formed coast, which is indented by a succession of parallel bays, with long bold promontaries between. Crossing Muskoka Lake there were, along our line of survey, two general courses, the first a few degrees east of north for about two and a-half miles, the second a few degrees south of east for about eight and three-quarter miles; these reached to the entrance of the main river into the lake. Conforming with the trend of its bays, promontaries, and islands, the length of Muskoka Lake, lying obliquely across the general bearing of the stream, is about N. W. and S. E.; its surface stretches far away to the southward of the latter of the two courses given above, probably from fifteen to twenty miles, but our survey was confined to the northern portion of the lake. Another large sheet of water called Lake Rousseau, lies about four or five miles a little west of north from Muskoka Lake, which receives its water by a stream coming in at the head of the most northerly bay; with the exception of a rapid, falling from eight inches to one foot, which occurs within a short distance of Rousseau Lake, the current on the connecting stream is scarcely perceptible.

Following the main river upwards from Muskoka Lake, in a course north of east, about four miles bring us to a bifurcation shewing two streams of nearly equal size, the one bearing away to the north, the other eastward; it is probable the eastward

stream may be considered the main channel, but we ascended by the north one. On a general bearing very nearly due north at a distance of about thirteen miles, we arrived at a series of very picturesque lakes, the lowest of which for distinction I named Mary's Lake. From the foot of this lake, which is about four miles long by an average breadth of from one and a-half to two miles, the course turns to N. N. E., and that bearing being carried on from the head of Mary's Lake for about four miles further, strikes another expansion which I have called Fairy Lake. The main stream comes in at the north-west angle of Fairy Lake, but that we did not follow; we crossed the lake in a direction about N. E. by E. to a small tributary at its eastern end, which we found to fall from a third lake nearly due east, at the distance of a little over one mile. This lake, which lies nearly east and west, is from two to three miles long, and from the peculiarity of its shape was called Peninsula Lake.

Here leaving this branch of the Muskoka, we made a portage of a mile and three-quarters over a height of land, our course being S. E., and reached a long narrow lake stretching away southward for several miles; this we termed the Lake of Bays. The waters of this lake flow into Muskoka Lake, by the channel of the eastern main stream, and as the south-west extremity of the Lake of Bays is not over fifteen miles from the position where the two main branches join, while its level is upwards of a hundred feet above Peninsula Lake, the course of the eastern branch must be extremely rapid, or broken by very heavy falls, the total fall to Muskoka Lake being 323 feet.

Into the Lake of Bays several streams fall, two of which are of considerable size; but the one at the northern end appearing to be the largest, we continued our survey along its course. It falls into a bay at the north-east angle of the lake, in lat. 45° 19′ N., long. 79° 4′ W. nearly; and from this point a bearing of about E. N. E., will in four miles strike the next lake on our course, named from its shape Ox-tongue Lake. The connecting stream between this lake and the Lake of Bays, with many meanders in its course,

makes a general curve to the south of the direct bearing that has been given.

Above Ox-tongue Lake the upward course is nearly due north for about two miles, until presenting a succession of heavy falls, where it first turns south of east for about two miles, and afterwards bends to north-east, which course, excluding many minor sinuosities, it maintains for eleven or twelve miles to Canoe Lake, so called from the circumstance of our being detained there for several days to construct a new canoe. Above Canoe Lake our course continued north-eastward through a series of small lakes and ponds, connected by short and narrow streams, generally rapid. The uppermost of the expansions was called Burnt Island Lake, and it is the highest on the Muskoka River. We attemped to follow a small stagnant brook which passes through a marsh at the northern extremity of Burnt Island Lake, but after progressing about two miles, all appearance of running water terminated in a vast swamp. From a bay at the north-east end of the lake we then crossed over a height of land, and at the distance of about half-a-mile, in the bearing N. N. E., we came upon a small lake which afterwards proved to be the head waters of the Petewahweh. The place of the portage is in lat. 45° 40′ 30″ N., long. 78° 38′ W.

The following tabular arrangement shews the relative heights of the various lakes of the Muskoka over the sea, assuming that of Lake Huron to be, as represented by the engineers of the State of Michigan, 578 feet:

Levels of the Muskoka.

	Distance. Miles.	*Rise.* Feet.	*Total Dist.* Miles.	*Height above the Sea.* Feet.	
Height of Lake Huron,				578·00	Lake Huron.
Rise in rapid on the Muskoka,.......		2·00			
—— in 1st fall,......		10·44			
—— in 2d fall,......		12·00			
—— in rapid, ...		1·00			
—— in 3d fall,......		13·11			
—— in 4th fall,......		30·64			

	Distance. Miles.	*Rise.* Feet.	*Total Dist.* Miles.	*Height above the Sea.* Feet.	
Rise in rapid, ...	¼	2·00			
—— in rapid, ...	¼	0·80			
—— in 5th fall, ...	¼	26·00			
—— in rapid, ...	¼	5·40			
—— in 6th fall, ...		15·00			
—— in current, ...	¾	0·60			
—— in rapid, ...		3·00			
—— in 7th fall and rapids, 6·00					
—— in fall and rapids, 4·00					
—— in fall and rapid, 8·00					
——	1	18·00			
—— in 8th fall, ...	¼	34·77			
—— in 9th fall, ...	¼	11·00			
—— in 10th fall, ...		23·44			
—— in current, ...		0·50			
—— in navigable parts of the stream between the rapids and falls, 8¾ miles, at 0·25 foot per mile, ...	8¾	2·19			
—— in lower lakes, which are not very great expansions, 8¾ miles, at 0·04 foot per mile, say, ...	8¾	0·31			
—— in Muskoka Lake, which is a very large expansion, inappreciable, ..	13¾	0·00			
	—— 34¼	—— 212·20	34¼	790·20	**Muskoka Lake.**
—— in fall, ...		51·70			
—— in fall and rapid .	¼	7·60			
—— in fall, ...		37·67			
—— in fall, ...		59·20			
—— in rapid, ...	⅛	1·50			
—— in fall, ...		11·00			
—— in rapid,........		1·50			
—— in rapid, ...	⅛	2·00			
—— in fall, ...		7·52			
—— in rapid, ...	¼	4·80			

	Distance.		*Rise.*		*Total Dist.*	*Height above the Sea.*	
	Miles.		Feet.		Miles.	Feet.	
Rise in fall, ...			12·50				
—— in navigable parts of the river, 19¾ miles, at 0·25 foot per mile, say,....	19¾		5·00				
	——	20¼	——	201·99	54¾	992·19	Mary's Lake.
—— in fall and rapid.	½		7·00				
—— in rapid, ...	¼		1·20				
—— in navigable parts of the river between the rapids, 4¾ miles, at 0·25 ft per mile, say....	4¾		1·00				
—— in Mary's Lake, inappreciable ...	3¼		0·00				
	——	8¾	——	9·20	63½	1001·39	Fairy Lake.
—— in rapid, ...	¾		5·92				
—— in Fairy Lake, inappreciable ...	2¾		0·00				
	——	3½	——	5·92	67	1007·31	Peninsula Lake.
—— in Peninsula La., inappreciable,...	2¾		0·00				
—— in Portage to La. of Bays,........	1¼		101·89				
	——	4	——	101·89	71	1109·20	Lake of Bays.
—— in fall, ...			22·00				
—— in rapid and fall.	1		49·00				
—— in rapid and fall.	¾		20·90				
—— in rapid and fall.	1		50·00				
—— in navigable parts of the stream between falls, &c., 4¼ miles, at 0·25 foot per mile, say	4¼		1·00				
—— in Lake of Bays, inappreciable ...	4		0·00				
	——	11	——	142·90	82	1252·10	Ox-tongue Lake.
—— in fall, ...	¼		77·50				
—— in fall, ...			30·00				
—— in fall, ... 3·00							
—— in fall, ... 1·50							
—— in fall, ... 3·00							
——	½		7·50				
—— in small rapid, .			0·50				
—— in small rapid, .			0·50				
—— in rapid, ...	¼		4·00				

	Distance. Miles.		*Rise.* Feet.		*Total Dist.* Miles.	*Height above the Sea.* Feet.	
Rise in strong rapid, .	½		9·00				
—— in Ox-tongueLake inappreciable ...	1½		0·00				
—— in navigable parts of the river between falls, &c., 18¾ miles, at 0.20 foot per mile,....	18¾		3·75				
	——	21¾	——	132·75	103¾	1384·85	Canoe Lake.
—— in falls & rapids.	¼		7·00				
—— in beaver dam, ..			1·50				
—— in rapid, ...	¼		4·00				
—— in rapid, ...			3·00				
—— in falls & rapids.	¼		5·00				
—— in Canoe Lake and Burnt Island Lake, ...	11¼		0·00				
—— in navigable parts of the river between falls and rapids, 2¼ miles, at 0·25 ft p. mile,	2¼		0·50				
	——	14¼	——	21·00	118¼	1405·85	Burnt Island L.

The country on each side of the Muskoka River, between Lake Huron and Muskoka Lake, is for the most part rugged and barren, bearing chiefly white and red pine, usually of small size. There are intervals, however, of better soil at various distances back from the river, where the pine timber which still prevails is of tolerably stout growth, and may eventually become of commercial importance. Since the time of my visit, Mr. W. B. Hamilton, of Penetanguishene, has erected a saw-mill on or near the first falls, about two miles from the mouth of the river, where he is said to have an almost inexhaustible supply of pine within easy distance. Should this attempt at lumbering prove successful, and the present prices for the manufactured article continue, it is not improbable that establishments may extend still further into the interior before many years, as the river affords every facility for using water power in a great many places.

The portion of the shores of Muskoka Lake which came under my notice, like the banks of the river below, is bold, rocky, and barren, which is also the case with Rousseau Lake, although in the latter some good land occurs in patches, which are partially cultivated by a tribe of Indians who have settled there.

Between Muskoka Lake and the junction of the two main streams above, the river passes through rich alluvial flats producing abundance of good-sized elm, soft maple, ash and other trees, among which there is scattered a considerable quantity of fine white pine. Above the junction for from five to six miles, up to the high falls on the branch which we followed, the forest still indicates tolerably strong land in a stout growth of pine and hemlock, but above that part it becomes less productive, the principal trees being stunted evergreens, mostly balsam-fir, on a light and generally sandy soil.

The coasts of the upper three lakes are occasionally precipitous, and, except in the valleys of little streams, are every where bold and rocky. These precipices, with the hills in the back ground rising three hundred or four hundred feet at a moderate distance, offered very picturesque scenery, which, however, possesses few recommendations for settlement or permanent improvement.

I was informed by the Indians of Rousseau Lake that a very extensive area of country, occupied by vast swamps, or interspersed with innumerable small ponds and lakes, tributary to the north branch, lay directly north from Fairy and Peninsula Lakes, where numbers of the tribe resorted during the hunting season, for the purpose of trapping beavers, which were represented to be very numerous.

The character of the coast of the Lake of Bays, like that of the chain of lakes, on the north branch, is rocky, bold, and barren, for the most part; but the valley of the river above frequently contains wide areas of alluvial flats, having clay of a drab colour as a subsoil, overlaid by silicious yellow sand. Groves of red pine were observed in many parts, both on the lakes and on the river, and instances were not altogether wanting where that timber attained a good sized growth, pro-

bably suitable for squaring into spars. The soil producing red pine, however, is not usually deemed to be of the best quality. At the height of land between the Muskoka and Petewahweh, and around the upper lakes, there are great tracts of marsh and swamp, closely grown over by stunted tamarack and dwarf spruce, or carpeted by marsh plants. These swamps occupy the valley between the ranges of hills, which are here widely apart, running about N. N. E. and S. S. W. On the sides of these hills there are frequently good hard-wood trees; many of them were white birch, the bark of which we found of essential service for building our new canoe.

The Petewahweh River.

Descending the Petewahweh, we found the higher waters of its course to consist of a chain of lakes, extending in a direction a little west of north, for the distance of about sixteen miles, in a straight line from the source. The lakes of the upper portion of the chain are connected by a small winding stream, scarcely to be called navigable, as the rapid parts are very shallow, and much of the remainder is blocked up by beaver works or drift timber. At the foot of this stream, about five and a-half miles north from the head, we struck a lake, which was readily recognised from its position to be the one represented on Bouchette's map as White Trout Lake; and, from ten to eleven miles farther down, on the next lake, we found a branch coming in from the westward, which was supposed to be the source struck by Mr. William Hawkins during his exploratory route in 1837. The lower two lakes of the upper series were found to be Red Pine Lake and Burnt Lake, so called upon Bouchette's map.

From the lower end of Burnt Lake the river bears off about E. N. E., for about five miles, when it again expands into an open sheet of water, called Cat-fish Lake. Below Cat-fish Lake, the river, in many parts, becomes exceedingly rapid and broken by heavy falls, running, as a general course, nearly N.E. for about six miles, when it empties into a large lake, called Cedar Lake. Cedar Lake lies immediately north of the 46th

parallel of north latitude, and the meridian of 78° 30′ W. passes across it near its centre. The lake lies nearly at right angles to the course of the river above, its bearing being about W. N. W. and E. S. E. It is from seven to eight miles long, with an average breadth of from half-a-mile to a mile and a-half.

The continuation of the river downwards flows from the eastern extremity of this lake with great velocity, on a general bearing of about east by south, for five miles, when it again opens out into Trout Lake. Below Trout Lake, the river continues a little to the south of east, and, in some parts, pent up in narrow gorges, it rushes on in violent rapids, or tumbles over precipitous falls, and again expands in wide open pools or basins, until it reaches Lake Travers, at the direct distance of ten miles. Entering this lake, the course bends northward, and is so maintained for a little over four miles; then, again contracting itself, the stream flows on very rapidly to the N.E., for between six and seven miles, and reaches the latitude 46° 4′ N., the most northerly point of our expedition. From that point the course gradually bends round to the south-eastward, and, with a few deviations, flows thus, in many parts very rapidly, to its junction with the Ottawa, on the Allumette Lake.

Otter-slide Lake, at the head of the Petewahweh, is on the same level as Burnt Island Lake, at the head of the Muskoka; and, taking this as a starting point, the following is a tabular arrangement of the heights of the lakes on the Petewahweh over the level of the sea:—

Levels of the Petewahweh.

	Distance.		*Fall.*		*Total Dist.*	*Height above the Sea.*	
	Miles.		Feet.		Miles.	Feet.	
Height of Otter-slide Lake, head of the Petewahweh River,						1405·85	Otter-slide Lake
Fall in Otter-slide Lake and in the river, to White Trout Lake,	7½		69·00				
	——	7½	——	69·00	7½	1336·85	White Trout L.

	Distance. Miles.		*Fall.* Feet.		*Total Dist.* Miles.	*Height above the Sea.* Feet.	
Fall in rapid, ... 3·50							
—— in rapid, ... 8·00							
——	½		11·50				
—— in rapid, ...			3·00				
—— in rapid, ...			1·50				
—— in White Trout Lake and others, with Burnt Lake, 10¾ miles, at 0·02 foot per mile, ...	10¾		0·22				
—— in navigable parts of the river between rapids, ¾ mile, at 0·02 foot per mile, ...	¾		0·18				
——		12	——	16·40	19½	1320·45	Burnt Lake.
—— in rapid, ...			5·00				
—— in rapid, ...	¼		10·00				
—— in rapid, ...			0·80				
—— in rapid, ...	¼		5·00				
—— in rapid, ...	¼		6·00				
—— in navigable parts of the river between rapids, 5½ miles, at 0·60 foot per mile, ...	5½		3·30				
——		6¼	——	30·10	25¾	1290·35	Cat-fish Lake.
—— in rapid, ...			2·20				
—— in rapid, .. 5·00							
—— in rapid, .. 9·57							
—— in rapid, .. 32·35							
——	¾		46·92				
—— in fall and rapid	¼		47·00				
—— in rapid, ...	¼		24·00				
—— in fall, ...			40·90				
—— in fall and rapid	¼		78·20				
—— in Cat-fish Lake, and other small lakes, 4½ miles, at 0·05 ft p. mile,	4½		0·20				
—— in navigable parts of the river between falls and lakes, 3¼ miles, at 0·38 foot per mile,	3¼		1·15				
——		9¼	——	240·57	35	1049·78	Cedar Lake.

	Distance. Miles.	*Fall.* Feet.	*Total Dist.* Miles.	*Height above the Sea.* Feet.	
Fall in rapids, ……		18·59			
—— in dam & rapids,	½	17·47			
—— in rapid, …….	½	36·10			
—— in fall and rapid,	½	46·00			
—— in Cedar Lake, 4¼ miles, at 0·03 foot per mile, say….	4¼	0·16			
—— in navigable parts of the stream between rapids, &c. 4 miles, at 0·50 ft per mile, …….	4	2·00			
	—— 9¾	——120·32	44¾	929·46	Trout Lake.
—— in rapid, …….		2·50			
—— in rapids, ……	¼	14·50			
—— in rapid, …….		2·00			
—— in rapid, …….	¼	9·00			
—— in rapid, …….	⅛	6·50			
—— in rapid, …….		3·50			
—— in rapid, …….	⅛	6·50			
—— in rapid, …….		1·00			
—— in cascade, dam and slide, ……	¼	22·00			
—— in succession of falls and rapids,	2	135·00			
—— in Trout Lake, 2¼ miles, at 0·05 foot per mile, …….	2¼	0·11			
—— in navigable parts of the stream between the rapids, 9½ miles, at 0·62 foot per mile,….	9½	5·89			
	—— 14¾	——208·50	59½	720·96	Lake Travers.
—— in rapid, …….	1¼	19·00			
—— in rapid, …….	¼	7·00			
—— in falls & rapids	1	48·50			
—— in rapid, …….		2·00			
—— in falls & rapids	1	30·00			
—— in succession of rapids, with intervals of smoother water, in all 2 miles, ………	1¾	27·50			

	Distance. Miles.	Fall. Feet.	Total Dist. Miles.	Height above the Sea. Feet.	
Fall in succession of rapids, with intervals of smoother water, in all 2 miles, ...	¾	12·00			
—— in rapid, ...		2·00			
—— in current, ...		0·50			
—— in rapid, ...	¼	10·00			
—— in rapid, ...		2·50			
—— in rapid, ...		3·50			
—— in rapid, ...	½	20·00			
—— in Lake Travers, 3¾ miles, at 0·04 foot per mile,....	3¾	0·15			
—— in navigable parts of the stream between the rapids, 31¾ miles, at 0·50 foot per mile,....	31¾	15·87			
	—— 42¼	—— 200·52	101¾	520·44	Fork of South Branch.
—— in fall and rapid	¼	14·50			
—— in fall and rapid	1	15·30			
—— in fall and rapid	¼	15·74			
—— in fall, ...		15·29			
—— in fall, ...		17·00			
—— in fall, ...		2·00			
—— in navigable parts of the stream between the falls, &c., 6½ miles, at 0·50 foot per mile,	6½	3·25			
	—— 8	—— 83·08	109¾	437·36	Lake Allumette

Between the height of Lake Allumette, as here deduced, and the height given to it in your Report of the Ottawa, in 1845, there thus appears to be a discrepancy of about forty-five feet, my figures being in excess.

When the rapids were long and of frequent occurrence, as was the case on the Petewahweh, and in one or two instances also on the Muskoka, we found that it occupied too much time to work out the rise or fall trigonometrically, and accordingly resorted to the readier, though less accurate, method of levelling by the clinometer. This was done by

looking along the edge of that instrument and fixing a point in advance or behind, on a level with the eye, the height of which was taken as a datum for our measurement upwards or downwards, as the case might be, the observation being repeated just as often as the whole rise or fall was equal to the height of the observer's eye above his feet. It may be the case, therefore, that the rise given to the Muskoka exceeds the reality, while the fall of the Petewahweh may be below it; and if half of my excess were taken from the one and given to the other, a pretty near approximation to the truth may probably be arrived at.

The head of the Petewahweh, like that of the Muskoka, is surrounded by vast swamps and marshes lying in the valleys between the mountain ranges, sometimes covered over with a stunted growth of spruce and tamarack, and occasionally opening into prairies with long coarse wiry grass and bushes. From White Trout Lake mountains are seen on the south-west and north, the latter rising abruptly 700 or 800 feet over its surface, and covered with pine, mostly of the red variety; from that lake downwards to the mouth of the river, the forest is chiefly of red pine. Although the quality of the timber on the upper parts may be good, its size is perhaps not sufficiently large to permit the extension of lumbering speculation in so remote a region; but the remains of surveyor's stakes, and the marks and numbers in several instances discovered on the trees, are sufficient evidence that timber locations have been projected.

The lumber trade has already extended to Cedar Lake, and farms in connexion with it have been established on that lake and at Trout Lake, and large supplies of squared timber are annually brought down to the Ottawa. A settlement appears at one time to have been attempted at Lake Travers, where produce would have had a ready market, as the lumber trade extended to the interior, but it has since been abandoned. The soil is everywhere exceedingly light, and although capable of growing good crops of hay or oats for a few successive seasons, it would soon be exhausted without an ample supply of manure, which, in such a position, could not easily be obtained.

There is much picturesque scenery on the Petewahweh, especially on Lake Travers and on the river below it, and fish and game abound in and around the upper waters. Speckled river trout were found on both this river and the Muskoka in immense abundance, sometimes reaching four pounds in weight, while beavers, deer, and other descriptions of game, were exceedingly numerous in all the remote and unfrequented parts.

The principal streams tributary to the Petewahweh are the Trout or Upper South Branch, the Levrier, and the Lower South Branch. The first of these falls into Trout Lake at its south-west extremity, and I was informed that its course is navigable in the early part of the season to within a short distance of the Great Opeonga Lake, one of the head waters of the Madawaska. At the time of our visit it was nearly dry in the rapid parts. The Levrier joins the main river about half-way between Trout Lake and Lake Travers on the south side, and is used to a considerable extent for floating down pine timber. The Lower South Branch comes in within six miles in a straight direction from the confluence with the Ottawa, and is, as I was afterwards informed, used as a route communicating with the head waters of the Bonne-chère. There are many other minor streams, some of which are partially navigable for small canoes, and contribute to the general supply of timber; and along the course of one, which falls in at the west end of Cedar Lake, a route is said to be known to the waters of Lake Nipissing.*

The variation of the compass above the fork of the Muskoka was found to be 5° 34′ W., and at Cedar Lake on the Petewahweh 6° 55′ W.

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* I have been informed by Mr. J. McNaughtan, P.L.S., that a tributary of the Petewahweh falls into Cedar Lake, in the marshy bay, about a mile westward of the entrance of the main stream into the lake. It is called the Little Nipissing, and by it there is said to be a route to Lake Nipissing. The mouth of this tributary being concealed by the marsh, I was not so fortunate as to observe it, and it is not therefore represented in the plan.

Route by the Bonne-chère River to Balsam Lake.

The Bonne-chère falls into the Ottawa at the Lac-des-Chats, in lat. 45° 32′ N., long. 76° 37′ W., the lower portion of its course passing through the townships of Horton, Admaston and Bromley. Up to the district line which divides the surveyed from the unsurveyed lands, its course lies nearly due east and west, the distance in a straight line being nearly twenty-one miles. Above the district line the general bearing up the stream is about west-by-north-half-north, for fifteen miles, within which distance it passes through Mud Lake and a succession of smaller expansions of still water, and terminates at the exit of Golden Lake. The main body of Golden Lake lies nearly north-west and south-east, and is rather over six miles in length altogether, the greatest breadth being from two to three miles. Falling in at the north-west angle of Golden Lake, the stream in its upward bearing continues about north-west for nearly four miles, and then turning off to the westward with many meanderings, makes a nearly west course to Round Lake, the exit of which is in lat. 45° 38′ N., long. 77° 30′ W., nearly. There are four sets of falls on the Bonne-chère, known as the first, second, third and fourth *chutes*, and several rapids; but with the exception of the *chutes* and a strong rapid between Egansville and Jessup's Landing farther up, over which portages have to be made, the river is very easily navigated the whole way. The lower or first *chute* occurs in the township of Horton, at a little over a mile from the mouth, making a fall of 32·66 feet. The second *chute* is also in Horton, near the village of Renfrew, where, in a succession of leaps and violent rapids, there is a fall of 82·21 feet. The third *chute* is in the township of Bromley, a little below the village of Douglass, and makes a fall of 21·00 feet. The fourth *chute* is about two miles above the district line at Merrick's Mills, where the fall is 38·11 feet, and the Egansville Rapids, which begin about seven miles above the district line, and are upwards of a mile in length, fall 44·07 feet.

According to our measurement the following table shews the height of the three principal lake expansions of the Bonne-chère, as taken from the level of Lac-des-Chats, over the sea:

Levels of the Bonne-chère River.

	Distance. Miles.	*Rise.* Feet.	*Total Dist.* Miles.	*Height above the Sea.* Feet.	
Height of the Chats Lake, as given in your Report of 1845, ...				233·09	Chats Lake.
Rise in the 1st or lowest chute,...		32·66			
—— 2d chute,.......	½	82·21			
—— 3d chute, below the village of Douglas, ... rapids, .. 2·00; rapids, .. 4·00; falls and rapids, ..21·00 ——	1½	27·00			
—— in rapid,.......	¾	7·50			
—— in rapid, ...	¼	2·50			
—— in rapid, ...	½	4·00			
—— in rapid, ...	¾	6·00			
—— in 4th chute, at Merrick's Mills ..	¼	38·11			
—— in succession of small rapids and swift current between, estimated at the rate of 3·00 feet per mile,	2	6·00			
—— in Egansville Rapids, ...	1	44·07			
—— in rapid, ...	½	3·00			
—— in rapid, ...	½	8·41			
—— in Borland's Rapids, ...	¼	2·56			
—— in navigable parts of river between rapids and falls, 25 miles, estimated at 0·50 ft. per mile,...........	25	12·50			
	— 33¾	—— 276·52	33¾	509·61	Mud Lake.
—— in Mud Lake to the junction of stream, no perceptible current, say, ...	1½	0·06			

	Distance. Miles.		Rise. Feet.		Total Dist. Miles.	Height above the Sea. Feet.	
Rise in rapid, ...	¼		4.62				
—— in navigable part between Mud La. and Golden Lake, estimated at the rate of 0·50 foot per mile, ...	3¼		1·63				
	—	5	——	6·31	38¾	515·92	Golden Lake.
—— in Golden Lake, rate estimated at about 0·05 ft. per mile, ...	7¼		0·37				
—— in a succession of small lakes, above Golden Lake, imperceptible current, estimated, as before, at 0·05 foot per mile, ...	5¼		0·26				
—— in rapid, ...			3.62				
—— in the navigable parts between the chain above Golden Lake and Round Lake, ...	1½		0·75				
—— in Round Lake, inappreciable, ...	4		0·00				
	—	18	——	5·00	56¾	520.92	Round Lake.

By this it would appear that Round Lake is nearly sixty feet lower than Lake Huron.

A remarkable subterranean channel occurs at the fourth *chute*, where a portion of the water turns abruptly off at right angles to the general course, running northerly for about ten chains through a great cavern in Lower Silurian limestone. The cavern is naturally nearly dry, except during freshets, but Mr. Merrick has used it to advantage by throwing a dam across the main body of the stream, near the middle of the *chute*, which turns a sufficient quantity of water through to convert the channel into a mill-race, and the fall from the lower end is applied to drive the water wheel of his mill.

There are many tributaries to the Bonne-chère, but they are for the most part of small size, and only partially navigable. The most important are Moore's Creek, which falls into the river about five miles below the third *chute;* Clear Creek, which joins a little above Egansville, two miles and a-half below Mud Lake; Brennan's Creek, which comes in at the south-west angle of Golden Lake; and the Little Madawaska, which flows into Round Lake at its south-western end; these three come in on the south side, while on the north side of Round Lake there is M'Mullin's Creek, and the continuation of the main river, commonly called the Little Bonne-chère, which enters the lake at the north-west extremity.

Clear Creek flows from a very beautiful sheet of water, called Clear Lake, which was reached by a nearly due south course from Mud Lake, at the distance of about eight miles. The south and west shores of this lake display land of very considerable agricultural capabilities, and are already to some extent settled.

There are many parts of the Bonne-chère country highly capable of cultivation, a great portion of which is already respectably settled, and settlements extend, more or less, the whole way up to within a short distance of Round Lake. Wherever the calcareous rocks occur, either of Laurentian or Silurian age, the country exhibits a superior quality of soil; on these, many good farms are already established, more particularly on those parts underlaid by Silurian formations, which, being in a nearly horizontal attitude, offer a more regular and level surface for the application of agricultural labour than the country occupied by the highly disturbed series of rocks on which they rest. Mr. Egans' farm, at Egansville, affords a good example of the capabilities of such land; here the tenant, Mr Sibury, an Englishman, has grown, as he assured me, excellent crops of wheat, oats, hay, potatoes, and other roots, besides having raised a large stock of horses and cattle, by the annual proceeds of which he has made a handsome profit, after deducting rent and all other contingent expenses.

The country generally, however, throughout the whole region is, in the meantime, essentially a *lumbering*, rather

than an agricultural district; and, although the greatest part of the timber on the main river has long since disappeared—a large portion having been swept away by fire, independent of that removed by trade—there are still vast quantities brought down the tributaries annually, and made to descend to the Ottawa by the course of the Bonne-chère. On our way up the stream, we repeatedly found it almost entirely blocked up with squared timber, sometimes for miles together.

From Round Lake we pursued our journey to Lake Kamaniskaik by the valley of the Little Madawaska; but that stream not being navigable for the canoes, except in some short intervals of still water, we were compelled to carry everything for the greater part of the whole distance. Our levels were continued across trigonometrically, by taking the bearing and an angle of elevation or depression by the theodolite, and measuring each distance by the micrometer telescope. As a portion of the country we had to pass through had previously been denuded by fire, and had since pushed up into an almost impenetrable thicket of under-brush and bushes, much difficulty was experienced in performing this work—Mr. Brown (my assistant) and myself alternately clearing our way through with a tomahawk, as we took a back or a forward sight.

Our course, on leaving Round Lake, first bore a little south of west, about two miles; it then turned about S. by W. for seven miles, and reached the point where we left the waters of the Bonne-chère. Crossing a height of land and still bearing in the same general direction for about two miles farther, we met with a small tributary of the Madawaska, striking it at a small lake at the head of a brook, which, running nearly due south, brought us, in about a mile, to the northern extremity of Lake Kamaniskaik. The rise on the Little Madawaska to Lake Kamaniskaik was found to be as follows:—

Levels carried from Round Lake, on the Bonne-chère, to Lake Kamaniskaik, on the Madawaska.

	Distance. Miles.		*Rise and Fall.* Feet.		*Total Dist.* Miles.	*Height above the Sea.* Feet.	
Height of Round Lake,					56¾	520·92	Round Lake.
Rise on Little Madawaska to end of 1st portage, say,	1		3·50				
—— on 1st portage, ..	1		68·91				
—— on 2d "	¾		37·55				
—— on 3d "	¼		10·61				
—— on 4th "	¾		32·25				
—— on 5th "	1½		121·92				
—— on 6th "	¼		28·30				
—— on 7th "	¼		32·18				
—— on 8th "	½		2·00				
—— in the navigable parts of the tributary to the portage to the Madawaska waters, estimated altogether at.........	3¼		2·20				
	——	9½	——	339·42	66¼	860·34	Source of Little Madawaska.
—— on 9th portage to height of land...	¾		107·99			968·33	Height of land.
Fall on 9th portage to a pond tributary to Madawaska R.	1¼		61·53				
	——	2	——			906·80	*Pd. tributary to Madawaska R.
—— at beaver dam, below pond, ...	¾		2·00				
—— on stream to Lake Kamaniskaik, ...	¼		1·00				
	——	1	——	3·00		906·80	L. Kamaniskaik.

It would thus appear that the Bonne-chère lies in a trough or hollow between the two larger streams—the Petewahweh and the Madawaska—at a much lower level than either, and that the tributaries of the two larger rivers almost encircle the head waters of the smaller one.

* In the topographical plans accompanying this Report, the height of this pond has been placed on Lake Kamaniskaik, making the lake 906·80 instead of 903·80 feet above the sea.

Excepting the portion that has been overun by fire, the forest between Round Lake and Lake Kamaniskaik consists almost exclusively of red pine, a large proportion of which is of very large size, and, so far as I could judge, of an excellent quality. This was found to be the case more particularly on the portage over the height of land, where hitherto the timber has for the most part not been disturbed by the axe of the lumberman, further than to *blaze* a trail to guide the traveller from one water to the other. The soil is generally light and sandy, as its vegetation indicates, and might be easily worked. The surface is nowhere rugged, rocky, or broken, but gently undulating, or in some parts level. It is therefore admirably adapted for good roads of communication.

The northern shore of that portion of Lake Kamaniskaik, generally known as Barry's Bay, where the creek falls in, is in lat. 45° 29′ N., long. 77° 40′ W., nearly. Barry's Bay lies nearly due north and south, and is a little over five miles long, with an average breadth of about half-a-mile; while the main body of Lake Kamaniskaik, which opens out from the south end of the bay, lies transversely to it, bearing about N. by W. and E. by S., with a length of three and a-half miles by two and a-half across its widest part. The main branch of the Madawaska falls into the latter portion of the lake, at its north-west angle, and leaves at its eastern extremity, whence it runs on a general course about S.E. for five miles, flowing on with a scarcely preceptible current, and frequently expanding into ponds or small lakes, to the junction with the Shawashkong, or Mishawashkong, the branch by which we continued our exploration.

There is a marked difference in character between the soil on the south side of Lake Kamaniskaik and that we had previously passed over to the north. Leaving Barry's Bay and the dense forests of pine by which it is surrounded, and emerging into the open expansion of the main lake, a hilly country, covered with hardwood trees, presents itself immediately opposite, extending as far as the eye can reach on either hand. Portions of this hard-wood country are highly capable of cultivation, and Mr Byers, a gentleman who for many years

has been connected with the timber trade, has established upon it, at the lower end of the lake, a farm, which, I was informed, yields good crops of oats, hay and potatoes. The surface, on Mr Byer's farm, was at first found to be rather stony, and large boulders would occasionally interrupt the regularity of a plough furrow, but it had been considered worthy of being cleared of these incumbrances, and the stones had been collected and piled in heaps on the fields, probably to be eventually used as fence walls, for the protection of future crops.

The lower portion of the Shawashkong is ascended by four general courses, which, with the exception of some minor turns, indicate pretty nearly the direction of the river.

1st S.S.W.	7	miles.
2d W.S.W. by W.	3¼	"
3d S. by W.	8¼	"
4th S.W. by W.	2¼	"

At the end of the last distance a sweeping southerly turn commences, known by the lumberers as the Great Bend. From the lower end of this bend the course upwards is first S.S.W. for about seventeen miles, it then turns sharply off to the north, and continues in that direction for over half-a-mile; it then proceeds easterly for half-a-mile, presenting a set of heavy falls, and resumes a southerly course for upwards of a mile, until reaching Egan's Creek, in latitude 45° 5′ N. Beyond this the valley lies nearly due east and west, for upwards of five miles, then turns to a general N. W. course, and after several curves, comprehended in seven miles, reaches the exit of Kaijick Manitou Lake. From the commencement of the Great Bend, to within a short distance of Kaijick Manitou Lake, the bed of the river is so exceedingly tortuous that were it drawn out into a straight line the distance would be nearly double that indicated by the general bearings. The lower portion of Kaijick Manitou Lake is narrow and crooked, but in a straight line it would be about S.W., for three miles; the upper part or main body of the lake lies nearly due east and west and is about three miles long, while the breadth for the most part is under and no where exceeds one mile. The north

shore of this part was found to be in lat. 45° 6′ N., and the line of long., 78° 0′ W., passes at nearly equal distances from the head and the foot of the lake. Above Kaijick Manitou Lake the valley of the river bears up about W. N. W., for from nine to ten miles to a small lake called Papineau Lake, the lowest of a chain which stretches along the height of land to the N. W.

The Shawashkong, as its name implies, flows in many parts through immense marshes, especially at the lower and towards the upper extremities. The marsh at the mouth extends uninterruptedly up the river, for rather more than five miles; the breadth between the hills on each side varying from half-a-mile to upwards of one mile. It is grown over almost entirely by reeds and marsh grass, with tufts of willow and other small bushes on the drier spots. Near the upper end of the marsh a tributary comes in called the Little Mississipi, the upward course of which is to the southward, and is said to be sometimes used as a route to the Mississipi River, which empties into the Lac-des-Chats. East of the outlet of the Madawaska, above the Little Mississipi, the river contracts and becomes more or less rapid in parts up to the Great Bend, and from thence upwards there is an alternate succession of falls and smooth water, but with a tolerably rapid current, till reaching Kaijick Manitou Lake. Between the Little Mississipi and Lake Kaijick Manitou, there are thirteen distinct falls or rapids.

The principal tributaries of the Shawashkong, in addition to the Little Mississipi, are Papineau's Creek, and Egan's Creek. The former comes in about two miles and-a-half above the Little Mississipi, flowing from the northward; the latter joins near the south-west angle of the Great Bend. A route is said to be known along the valley of Egan's Creek, leading to the settlements in the township of Madoc.

Tracts of good hard-wood land mixed with pine, occur in the valley of the Sahwashkong, particularly in the flat country around the Great Bend and at Kaijick Manitou Lake; but the prevailing forest is pine throughout the length of the river. Farms have been established at two places, one at a short dis-

tance above the Little Mississipi, by Mr. Conroy, and another further up and near the Great Bend, by Mr. Egan. Lumbering operations have already extended nearly up to Kaijick Manitou Lake, and I was informed by the Chief of a tribe of Indians I met there, that preparations were about to be made to bring timber down from the country above Papineau Lake. The name of Kaijick Manitou was given the lake in honor of this Chief, who proved of great service to us by his description of the country we were about to travel through at the height of land.

Between Kaijick Manitou and Papineau Lakes the river flows sluggishly through a vast marsh, making a very serpentine course through the valley, which is bounded on either side by hills of moderate elevation, frequently clothed with good sized hard-wood trees. Although there is a perceptible current for the whole distance, the rise in this part is very small, certainly not amounting to more than six or eight feet.

The following is a tabular view of the rise on the Shawashkong :—

Levels of the Shawashkong from Lake Kamaniskaik.

	Distance. Miles.	*Rise and Fall.* Feet.	*Total Dist.* Miles.	*Height above the Sea.* Feet.	
Height of Lake Kamaniskaik, at the head of Barry's Bay, above the sea,...				903·80	Kaminiskaik Junction.
Fall in Lake Kamaniskaik, from head of Barry's Bay to outlet at Byer's Farm, 0·05 ft. per mile, say	7¾	0·39			
—— in Madawaska, from outlet to junction of Shawaskong, 0·10 ft. per mile, ...	5	0.50			
	— 12¾	—— 0·89		902·91	

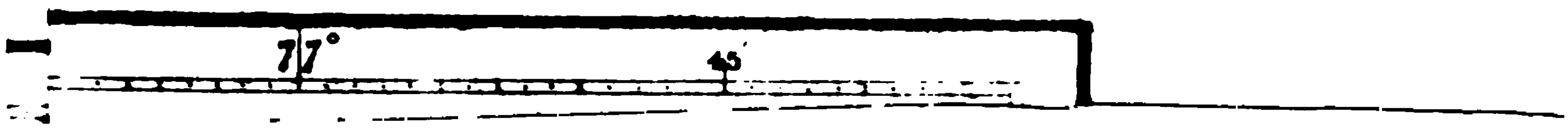
	Distance. Miles.	Rise and Fall. Feet.	Total Dist. Miles.	Height above the Sea. Feet.
Rise in navigable waters, from the junction to the mouth of Little Mississippi, current very slight, estimated at 0·10 ft. per mile,.....	5½	0·55		
—— in the navigable water above Little Mississippi to junction of Conroy's Rapids, estimated at 0·50 foot per mile,.......	2	1·00		
—— in Conroy's Rapids	¼	3·00		
—— in rapid,.......	¼	2·50		
—— in the navigable water above Conroy's Rapids to Papineau's Creek, estimated altogether at, say,....	1	0·80		
—— in rapid,.......		6·01		
—— in fall,.........		18·50		
—— in rapids,......		8.70		
—— in falls,........		34·30		
—— in falls and rapids,...........	¼	23·00		
—— in falls and rapids,...........	¼	20·15		
—— in rapid,.......		5·62		
—— in rapids and fall,...........		24·96		
—— in falls,........		37·38		
—— in rapid,.......		0·80		
—— in rapid,.......		3·58		
—— in rapid,.......		0·60		
—— in the navigable water between falls and rapids, estimated at 0·50 foot per mile, say	21¾	10·95		

	Distance. Miles.		Rise and Fall. Feet.		Total Dist. Miles.	Height above the Sea. Feet.	
Rise in the navigable water between falls and rapids, estimated at 0·70 foot per mile,...	10		7·00				
—— on surface of small lakes below Kaijick Manitou, estimated at the rate of 0·10 foot per mile,...	2¼		0·22				
	—	43¾	——	209·62	43¾	1112·53	Kaijick Manitou Lake.
—— on Kaijick Manitou Lake, estimated at 0·05 ft. per mile,........	7		0·35				
—— in the navigable water on the stream to Papineau Lake, estimated at 0·80 foot per mile,........	11		8·80				
	—	18	——	9·15	61¾	1121·68	Papineau Lake

Papineau Lake by this estimation, ...	1121·68
Balsam Lake, by Bouchette's map,.................	823·00
Difference of level,........................	298.68

Above Papineau Lake there are occasional rapids, connecting a chain of lakes at the main source of the river, but the elevation of them was not ascertained; for shortly after leaving Kaijick Manitou Lake, our provisions were exhausted, and we had necessarily to abandon farther measurements, and make the best of our way to the settlements. Fortunately beavers, muskrats, and other game were tolerably abundant, and supplied our necessities until we arrived at Kah-shah-gahwigamog, where we fell in with a trapper, named Russel, who kindly provided us with venison and bread.

Continuing our journey from Papineau Lake, our course was nearly south-west for about seven miles, within which distance we portaged over to and crossed a succession of small lakes stretching along the water-shed situated between the Ottawa and Lake Ontario. The next course was a little


77°
45′

south of west, with a straight distance of about eighteen miles, crossing from one lake to another along the height of land, and at length reaching Kah-shah-gah-wigamog, or Long Lake, the waters of which fall into Cameron's Lake, by the channel of the Burnt River. This lake is narrow, and lying about S. S. W. as a general bearing from its upper end, has a length of a little over thirteen miles. The outlet leaves the lake on its south-east side, not far from the south-western extremity; this we did not follow, but from the south-west end, pursued a course nearly due west for a little over two miles, making in the distance two portages and traversing a small lake, and then striking the Gull River. The course of this stream was followed downwards through Gull Lake and the two Mud-turtle Lakes to Balsam Lake, making a course nearly due south, with a straight distance of about eighteen miles.

The waters of the first part of our course from Papineau Lake probably all belong to the Ottawa side of the ridge, and may fall into the Shawashkong, but all the others evidently go the other way, and most probably are upper waters of the Ottonabee.

The country all along the height of land is more or less broken and hilly, and the sides of the hills are amply covered with hard-wood trees intermingled with pines. The valleys and more level parts, except where swamps or marshes occur, frequently display an excellent soil, yielding a stout growth of maple, elm, birch and beech. There are also good tracts of land around Kah-shah-gah-wigamog and Gull Lake; and I was informed by the trappers I met there, that the country east of the latter lake was well adapted for settlement over a large area. Settlement has already begun on the Gull River, north of Balsam Lake, and will most probably soon extend still farther back. When I visited the same country in 1852, a saw-mill was in progress of construction on the lower rapids of the Gull River, which has since been finished and put in operation; below it there are now several clearings, with houses and barns on them, where all was a wilderness one twelve-month before.

DISTRIBUTION OF THE FORMATIONS.

As nearly the whole region of which the above is a geographical sketch, is occupied by a very ancient set of rocks which are almost every where corrugated, dislocated, or otherwise disturbed, it will be obvious that to acquire in the course of a season any definite knowledge as to their geological arrangement over so large an area, would be a matter of impossibility.

To work out the physical structure of such a district, many lines of exploration must be measured, and the geological facts registered on each; in order that the whole being mapped in their proper relations, they may be ultimately compared, with a view of following out the distribution of stratigraphical groups. The new information collected on the present occasion, regarding the superposition of the members of this most ancient and altered series is perhaps very limited; yet something is added to our knowledge of their distribution as a whole, and such observations as have been made may afford tolerably good data as starting points for more minute and more perfect stratigraphical investigation hereafter.

Laurentian Series.

With the exception of some outlying patches of the Lower Silurian formation met with in the valley of the Bonne-chère and its tributaries, the Laurentian series occupies the whole region traversed during the season on the Muskoka and the Petewahweh. The rocks are for the most part micaceous and hornblendic gneiss, sometimes interstratified with fine-grained granular quartzose layers, which frequently hold small pink garnets. The prevailing color of the gneiss is red or grey; the more micaceous beds have the character of mica slate, usually dark grey or blackish, and the more hornblendic sometimes present the form of hornblende rock, the colors of which are black or the darkest shades of green. In many parts the stratification is very obscure, and except for the parallelism usually displayed by the constituent minerals on fracture, could not be detected; in other instances it

is well defined by alternating layers of different colors and mineralogical characters, arranged with great regularity in bands not exceeding the eighth of an inch thick. The garnetiferous portions are usually yellowish, or yellowish-white, consisting of an aggregate of granular quartz, with the garnets distributed irregularly through the mass, sometimes in clusters, at others in single individuals. Beds of this description are seen to alternate with mica slate and red or grey gneiss; in which cases the stratification is very clearly dedeveloped. These rocks are nearly every where intersected by veins of various thicknesses, the majority of which are of feldspar and quartz, usually coarser grained, and more conspicuously crystalline than the rocks they cut; but occasionally they are of a fine grain. The prevailing color of the finer grained veins is flesh-red, from the predominance of red feldspar. Veins of white semi-transparent quartz also occur, and these generally are more or less charged with iron pyrites.

Garnetiferous gneiss was observed at one or two places on the Muskoka, below Muskoka Lake, but was much more largely developed at Fairy Lake and the Lake of Bays. On Fairy Lake, garnetiferous beds occur on the western shore, and on the largest island, interstratified with fine-grained grey micaceous gneiss, and show a dip S. $<25^{\circ}$ to 30°. They were met with also near the south end of the portage, between Peninsula Lake and the Lake of Bays, in a cliff rising from the brink of a small pond, and in several parts of the Lake of Bays, particularly on the point, at the narrows on the east side, about half-way down the lake. At the falls above Ox-tongue Lake, strata, in very regular beds, occur, consisting of alternations of white and yellowish quartzite, sprinkled very thickly with garnets, with regular layers of grey and reddish gneiss and mica slate, which show a dip of S. 60° E. $<32^{\circ}$.

A black rock, composed chiefly of hornblende, rather coarsely crystalline, with a small portion of black mica disseminated in it, comes out on the Muskoka, below the falls a little south of Mary's Lake, which, from its position with regard to the general run of the gneiss, was supposed to be intrusive.

The contact of this rock with the gneiss is concealed, but at the falls, a short distance higher up the river, the gneiss seems to be suddenly turned from its general course, and exhibits a repetition of sharp twists and corrugations, as if near the seat of some violent disturbance.

A black rock, of very similar character and appearance, was met with on several parts of the Petewahweh. It was usually associated with a very fine-grained brick-red ferruginous rock, composed chiefly of feldspar and quartz, which in some parts had the aspect of an obscure hornblendic gneiss, and in others that of a fine-grained syenite ; and the gneiss in its vicinity, when the stratification could be distinctly made out, being always shattered and dislocated, I was disposed to consider the red rock intrusive.

This red rock was seen at intervals on the Petewahweh, from Cedar Lake down to the mouth of the river, frequently forming bold vertical cliffs, which, in one instance, rose perpendicularly from the river to the height of 250 feet. The rock has a conchoidal fracture, and is usually intersected by small greenish colored veins, supposed to be chlorite, which also penetrate the adjacent gneiss. The black hornblende rock is usually very pyritiferous, and the associated red masses are frequently highly ferruginous, at times giving a bright red color to the soil on the surface. Where the gneiss comes in contact with the red rock, it often so nearly resembles the adjoining mass that it can only be distinguished from it by closely observing the continuity of the parallel arrangement of the mineral layers, which ceases at the junction. This was especially observed at the lower end of Cedar Lake, where the probability of the mass being intrusive first suggested itself.

At the northern sweep taken by the river below Lake Travers, a portion of the gneiss is dark green, and appears to contain epidote, while other portions are dark grey, with many disseminated red garnets. The fine-grained and supposed intrusive red rock is in close proximity with both these varieties, being seen in the river, both above and below where they occur, but whether interstratified with, or intersecting the gneiss, was not satisfactorily ascertained.

As garnetiferous gneiss has usually been found in close proximity to the calcareous portions of the series, with which many minerals of great importance are frequently associated, and as these calcareous portions afford the readiest means for tracing out the intricate folds and contortions which these rocks have sustained, a diligent search for the limestones was made on many parts of the Muskoka and Petewahweh, but without success. I have heard, however, since my visit, that some of the rock has been burnt for lime on the north side of Cedar Lake, but whether from boulders or a mass *in situ*, seems uncertain.

The general strike of the rocks comprehended in the first section of the exploration—that is on the Muskoka—is nearly N.E. and S.W., and the prevailing dip is south-easterly; but there are numerous great undulations, independent of minor folds and intricate contortions, which are in some degree correspondingly indicated by the several great turns of the main streams. On the Petewahweh, however, the rocks are so generally affected by dislocation and disturbance, especially below Cedar Lake, that the attitude displayed by the stratified portions is not to be much relied on, except for short distances.

In the valley of the Bonne-chère, crystalline limestone is extensively displayed, associated with gneiss, mica slate, and hornblende slate. The general strike of the rocks on the lower part of the river varies from N. 41° E. to N. 35° W., the dip being easterly; but, at the second chute, where there is evidence of great disturbance, the general run turns nearly east and west. In the rear of the village of Renfrew, a little south from Hurd's Creek, a ridge of gneiss, where the stratification is distinctly developed, shows a dip N. 12° E. $<30°$. This dip would carry the gneiss below a ridge of crystalline limestone, which rises immediately north of the village, and appears to strike for the second chute, where the bed of the river is crystalline limestone.

On the opposite side of the valley, about one mile back from the river, the Pinnacle Hill rises to the height of 356 feet above the upper part of the chute. The side and top

of this hill exhibit alternations of gneiss and hornblende slate, with some beds of crystalline limestone, running nearly due east and west with a southerly slope, at a very high angle, sometimes attaining ninety degrees. About half-way between the second and third chutes, where a section is exposed of gneiss with crystalline limestone at the base, the strike is at right angles to the course of the river, the dip being E. $<40^{\circ}$; but at the third chute, a ridge of crystalline limestone occurs on the north side, ranging nearly east and west.

Above the third chute, the exposures are of the older series of rocks, and consist of gneiss, until reaching Mud Lake, where a ridge of crystalline limestone again appears on the north side, about 200 yards back from the lake, running east and west; but the country crossed to the south of Mud Lake, between it and Clear Lake, although in great part concealed, exhibits gneiss wherever the rock comes to the surface. The north-east side, and the islands at the east end of Clear Lake, are all of gneiss.

Crystalline limestone was observed to extend along the eastern shore of Golden Lake, associated with coarsely crystalline beds or masses of flesh-red feldspathic rock, and a mixture becoming dark green from the presence of pyroxene in very large quantity, with scapolite, graphite, and mica disseminated. The run of the ridges on the north side of the lake is about N.N.E. and S.S.W., but to the southward and near the eastern end, the strata appear to bend round and dip S.S.E. $<10^{\circ}$ to 12°. The hills which rise over the north side of the lake and form the peninsula which nearly divides it, are gneiss.

Gneiss occurs in bluffs and ridges on the river, above Golden Lake and at Round Lake, at the latter showing a dip from north-east to north. Running parallel with these ridges, and apparently in the stratification, are masses of an aggregate of coarsely crystalline feldspar with quartz, which, with the adjacent gneiss, are cut by veins of similar character, holding grains and small isolated patches of magnetic iron ore.

Crystalline limestone is quarried at Renfrew, and is used for building purposes, and for burning into lime. Although rather too coarsely crystalline to be used as an ornamental marble,

it is sufficiently compact to dress well, and make a handsome and substantial building stone; it is likewise said to yield an excellent quality of very white lime when burnt. Portions of the limestone are of a flesh-red colour, which was observed particularly at the first chute, and at Golden Lake, where in each case the rock appears to be magnesian, perhaps a dolomite.

In the country south of Round Lake, and around Lake Kamaniskaik, the exposures observed were all gneiss, frequently cut by large feldspathic veins, which in some instances, especially at the latter locality, were characterised by holding numerous small isolated masses of magnetic iron ore. Reaching the valley of the Shawashkong, the crystalline limestones are again largely displayed. The valley of that stream seems to run almost exactly along the strike of the rocks, many of the abrupt turns apparently conforming to the contortions and twists in the strata, until arriving at the south-west angle of the Great Bend, above which it crosses the measures in its north westerly course, towards Kaijick Manitou Lake, exposing alternations of gneiss and crystalline limestone all the way.

On Kaijick Manitou Lake, and the country beyond, all the rock exposures observed were gneiss, and no limestone was seen throughout the remainder of the route, till reaching the Mudturtle Lakes, north of Balsam Lake, where it had been found the previous season.

The crystalline limestones on the Shawashkong resemble in all respects those described in former Reports as seen in other parts of the country. The prevailing color is white, or white mixed with grey; but there are also beds of a deep dull blue color, some of yellowish-white tinged with a flesh-red hue, and others having a whitish hue with a great admixture of dark green. Small spangles of plumbago are almost invariably found disseminated through all the varieties, but more especially in the white and grey colored portions, and pyroxene, scapolite, tourmaline, sphene, black and white mica, and iron pyrites, are very generally disseminated. The blue beds were only observed at two places on the river, the first being near the north-west angle of the Great Bend, while the

second was about the middle part of it, at a set of falls and rapids. In each case these bands were underlaid by a very micaceous dark grey gneiss, and overlaid by white crystalline limestone. Where the rock is tinged with flesh-red it is probably magnesian like that of the Bonne-chère, while the green portions owe their color to the presence of pyroxene, of which mineral some of the beds are almost entirely composed. The latter two varieties were chiefly observed near the base of a section, at a short distance below the outlet of Kajick Manitou Lake.

Fossiliferous Formations.

In the valley of the Bonne-chère, there are three detached outlying patches of Lower Silurian strata, each of which lies longitudinally with the course of the river. The first met with, and lowest in the valley, is almost entirely on the south side of the river, extending from the neighbourhood of Moore's Creek to the head of the third chute; the greatest breadth of this outlier is about a mile and a-half, the southern boundary being marked by the valley of Moore's Creek on the one hand, and partly by another small stream, falling in above the third chute, on the other. The fossils and general characteristics of the rock exposures here indicate strata between the Calciferous and Trenton formations, the latter inclusive. A section, measured at the third chute, exhibits the following beds in the ascending order :—

	ft.	*in.*
Red and green shales, with an arenaceous band interstratified, about one foot thick, weathering bright yellow; a few bilobated forms, supposed to be fucoids are met with	10	0
Concealed for about	20	0
Green calcareous shale, dip N. 37°, E. <13°	1	0
Pale green arenaceous limestone in thin beds	1	0
Dark grey, very bituminous limestone in irregular beds, separated by thin pellicles of bituminous shale	2	0
Grey bituminous nodular beds of limestone, in thin irregular layers, passing into a compact bed of grey arenaceous yellow-weathering limestone	3	0
Dark grey limestone, in a strong bed, bearing some resemblance to water-lime, and holding crystals of calcspar	1	6
The same rock, but darker in color, with beds weathering yellow	1	6
	40	0

The strata are then affected by a dislocation running N. 62° W., and S. 62° E.

The section being continued beyond the fault, is as follows:—

	ft.	in.
Blackish and green argillaceous shale, dip N. 39°, E. <13°	17	0
Pale greenish arenaceous limestone	0	9
Blackish or dark brown, very bituminous argillaceous shaly limestone	1	4
Dark brown or blackish bituminous shale	0	9
Dark brown earthy bituminous limestone, weathering yellow	1	10
Drab and dark blue limestone, with crystals of calcspar, in a compact bed	1	0
Dark grey nodular shaly limestone	1	2
Black and dark brown bituminous shale	1	0
Green shale	2	3
Greenish and drab colored shaly limestone, partially a whetstone bed	1	6
Yellow arenaceous limestone	1	2
Dark grey arenaceous limestone	1	2
Dark grey compact arenaceous limestone, in thin beds	1	8
Blackish bituminous limestone, in some parts shaly	2	0
Green arenaceous limestone	0	6
Greenish shaly limestone	1	0
Blackish grey silicious limestone, compact and hard, holding *Cythere*	0	6
Thin-bedded shaly limestone, with obscure organic remains, casts of *Cythere*	1	6
Bluish-grey compact silicious limestone, holding small patches of calcspar, and presenting fucoids on weathered surfaces	2	6
	40	7

At the falls, a little below where the above section was measured, there is a vertical exposure, displaying the following beds, in ascending order:—

	ft.	in.
Greenish shaly limestone, with shale at the top	4	0
Drab colored, fine-grained, slightly arenaceous limestone, weathering yellow; it has a conchoidal fracture, and is supposed to be a whetstone bed.	6	8
A yellow-weathering arenaceous limestone, with many cavities holding dog-tooth spar.	0	7
Pale grey, yellow-weathering arenaceous limestone, divided into beds of from 6 inches to 1 foot.	10	0
Grey compact limestone, holding numerous fossils, mostly obscure, among which are orthoceratites and some turbinated shells	2	6
Shaly limestone	0	8
Beds of grey limestone, alternating with green shale	4	0
	28	5

The fossiliferous rocks, which spread over the larger portion of the area south of the river, are of the Chazy age, but they are surmounted by beds holding fossils of the Black River and Trenton formations, at two places; one of these is near the western extremity of the patch, in the south-west corner of the township of Bromley, the other near its centre, on the twenty-fifth lot of the fifth range of Admastôn.

The second outlying patch is first exposed on ascending the river about three-quarters of a mile above the third chute, and extends to the westward to about one mile above the fourth chute. The lower part of the section is of red and green shales, with occasional green and yellowish arenaceous bands interstratified, and partings of green and yellowish shale; some surfaces have faint impressions of fucoids. A fault, running obliquely to the river, brings down a bed of arenaceous limestone, resembling the whetstone rock in the upper part of the section at the third chute, and red and green shales come up from below it, further up the stream. The strata are affected in several places by small dislocations, and at one place a bar of igneous or altered rock—probably a portion of the Laurentian formation—runs across the river, bearing N. 65° W., and S. 55° E.

In the valley of a brook, about one mile above the district line, red and green shales are exposed, with black shales overlying them, over which are beds of limestone, of the Chazy formation. Limestones of that age are exposed on the river, from above the brook up to the fourth chute, where the following section occurs, in ascending order:—

	ft.	in.
1. Blackish-grey bituminous limestone, a solid bed	0	6
2. Dark grey limestone, in irregular beds; it is very bituminous, and holds numerous small fossils	1	3
3. Greenish-grey calcareous shale, with some thin bands of dark grey limestone	2	3
4. Black bituminous limestone	0	3
5. Dark grey nodular bituminous limestone and shale, in irregular beds	2	2
6. Similar rock, with a strong compact bed in the middle; the upper surface shows *Columnaria alveolata*	2	6
7. Nodular bituminous limestone and shale	0	6

	ft.	in.
8. Grey bituminous limestone, in a strong bed, with numerous large orthoceratites	1	3
9. Dark grey, slightly shaly limestone, portions of which are of a very fine texture	1	7
10. Blackish-grey, very compact limestone, in one solid strong bed	0	8
11. Dark grey shale, with irregular thin beds of limestone containing numerous fossils, among which are fragments of trilobites and *Cythere*	5	0
12. Pale grey granular limestone, with *Columnaria alveolata* and small spiral shells	2	4
13. Shaly nodular limestone	1	0
14. Compact drab colored limestone, with many corals on weathered surfaces	3	6
15. Thin-bedded shaly limestone, with partings of shale; there are large corals at the base, and encrinites on the upper surface	1	6
16. Grey thin-bedded limestone weathering black, with fossils, chiefly encrinites, *Atrypa*, *Leptæna*, small corals and *Orthoceras*	1	6
17. Thin irregular beds of blackish-grey limestone	3	2
18. Grey bituminous limestone, in strong beds, with *Columnaria olveolata*, and other corals, and large sized stems of encrinites	3	3
19. Grey encrinal limestone, with *Columnaria alveolata* and other corals; the lower beds are not well exposed	7	0
20. Whitish-grey, coarse-grained limestone, with numerous corals, and a large convoluted shell	5	0
	46	2

Still higher beds were observed a little distance from the head of the chute, holding *Columnaria alveolata* and other corals, and the same large-sized convoluted shell.

The third and highest outlying patch continues from the foot of Jessup's Rapids, about three miles above the fourth chute, to the head of the Egansville Rapids. The breadth does not appear anywhere to be over three-quarters of a mile, and is sometimes less. Most of the area exhibits fossils of the Black River and Trenton formations, but above Jessup's farm, at the lower end of the Egansville Rapids, where the strata are affected by a succession of small dislocations, lower measures are brought up, including a bed of yellow-weathering arenaceous limestone, resembling the whetstone rock of the Chazy. In the lower part of this bed occasional vertical cylindrical forms, resembling *Scolithus linearis*, were observed.

Below Jessup's farm, fossils of the Trenton formation were found in great profusion, and one bed was characterized by holding nodules and large angular fragments of black chert. At the upper end of the Egansville Rapids, *Leptæna sericea*, *Chætites lycoperdon*, and *Lingula* were very abundant, with other fossils of the Trenton formation.

Portions of the fossiliferous formations were also observed on the south side and at the western end of Clear Lake, all of which contained fossils of the Trenton age; but the area over which these may spread has still to be ascertained.

Drift.

Large portions of the valley of each of the rivers are covered by superficial deposits of clay or sand, and as the latter usually occupies the surface and higher grounds, it spreads occasionally over very extensive areas.

Stratified clays were found on the Muskoka, between the Lake of Bays and Ox-tongue Lake, at the height of about 400 feet above the level of the sea; the banks there expose a section of ten or twelve feet in thickness, of drab or light buff colored clays, alternating with very thin layers of fine yellow or greyish sand. At one place, the beds are tilted, shewing a westerly dip of about eight degrees, in which they exhibit slight wrinkles or corrugations. These clays did not appear to give any effervescence in acids, but were found by Mr. Hunt to contain a very small proportion of lime. Coarse yellow sand overlies the clay, and spreads far and wide over the more level parts, generally forming the bank of the river, where not occupied by hard rock. On the Petewahweh, especially below Cedar Lake, the whole of the level parts are covered with sand, which in some places must be of great thickness.

The banks of the Bonne-chère display a great accumulation of clay at many parts below the fourth chute, sometimes exposing a vertical thickness of from seventy to eighty feet. Near the mouth of that river, below the first chute, where the clays form the right bank, and are upwards of fifty feet high, they are chiefly of a pale

bluish-drab colour and are calcareous, while other clays found higher up the stream, are of a yellowish-buff, and do not effervesce with acids. Below the second chute, buff colored clay is interstratified with beds of sand and gravel, the latter sometimes strongly cemented together by carbonate of lime, the whole being overlaid by a deposit of sand. The gravel is seldom very coarse, although an individual boulder may occur here and there amongst it, and it is chiefly derived from the rocks of the Laurentian series.

Sand is extensively distributed over the plains of the Bonnechère, and over a large portion of the area between it and the valley of the Madawaska. Most of the valley of the Little Madawaska is covered with sand on either side, and the country between its head waters and Lake Kamaniskaik is one continuous sandy plain. Near the summit level, on the portage to Lake Kamaniskaik, a conical-shaped depression was noticed in the sand, measuring about 150 links in diameter, with a depth vertical to the area of about 50 links. As such symmetrical depressions are not unfrequent in the calcareous rocks of the Silurian and Laurentian formations, it was supposed probable that it might indicate the presence of limestone beneath.

No organic remains whatever were detected characterising these drift deposits, and consequently there is no direct evidence whether their origin should be attributed to the action of salt or fresh water.

I have the honour to be,

Sir,

Your most obedient servant,

ALEX. MURRAY,

Assistant Provincial Geologist.

REPORT

FOR THE YEAR 1854,

OF

ALEX. MURRAY, Esq., ASSISTANT PROVINCIAL GEOLOGIST,

ADDRESSED TO

WILLIAM E. LOGAN, Esq., PROVINCIAL GEOLOGIST.

MONTREAL, 11th *June*, 1855.

SIR,

During the summer and autumn of 1854, I was employed, as you were pleased to direct, in making further exploratory examinations of the main topographical and geological features of the country lying between Lake Huron and the Ottawa River, in continuation of the surveys of the previous year. The portions thus examined and surveyed are the valley of the Meganatawan River and part of the coast of Lake Nipissing, with several of their more important tributary streams and adjoining lakes. The measurements and bearings were effected by the same process as on former occasions, while to insure the greater accuracy, a continual check was kept on the work by triangulation, when such could be conveniently carried on, as at Lake Nipissing; meridian altitudes of the sun and moon were frequently taken to correct our latitudinal positions. The whole has been carefully mapped on a scale of one inch to a mile, and the map, with all the ascertained facts recorded on it, I now beg to submit for your approval in conjunction with this Report.

The Meganatawan River.

The entrance from Lake Huron to the estuary at the mouth of the Meganatawan, represented in Bayfield's chart as the Byng Inlet, is in lat. 45° 45′ 48″ N. and long. 80° 40′ W. This estuary extends nearly due east about six miles, with a breadth varying from five to twenty chains or upwards; at the end of the distance it suddenly contracts to about two chains, and a tolerably rapid current is perceptible. Above the part where the river proper joins the estuary, the general course upwards is very nearly due east for about twenty-two miles, in which it makes a few southerly sweeps, and thus reaches a lake of considerable size, called for distinction Wahwaskesh, or Deer Lake. Between the estuary and Wahwaskesh Lake there are numerous falls and rapids, alternating with reaches of still water, sometimes expanding into small lakes. The rise on the river as far as Wahwaskesh Lake is about 137 feet, making this lake 715 feet above the sea. Within the first southerly sweep and about six miles and a-half above the estuary, the river is split into two branches, which reunite about nine miles higher up, but as the northern branch was the one followed through, the southern one is indicated on the map only at the junctions.

Wahwaskesh Lake stretches due south from the general course of the stream for about four miles, but contracts about the middle of that distance into a narrow strait, only a few chains in width at some parts; so that there are two open expansions, of about equal size. The main river flows into the lake at its north-eastern extremity, and the course above the junction is about E.S.E., for about six miles, to Maple Island, where there is a succession of small lake expansions; it then becomes almost due east for about four miles, and turns S. E. by E. for three miles more, reaching a long narrow crooked lake, called Aumick, or Beaver Lake, from the presence of beaver in the neighbourhood. Between Wahwaskesh and Aumick Lakes there are numerous falls and violent rapids, and the elevation of Aumick above Lake

Huron is 320 feet, or 898 feet above the sea. Above Aumick Lake, the river becomes very sinuous, making short reaches to the northward, alternating with long ones pointing on the average about S.E.; with many minor turns and elbows in the narrow and the still parts, the average of the whole would give a straight course nearly E.S.E. for twenty-two miles, to a turn on the main river at its most southerly part; this was found to be in latitude 45° 32′ 40″, where the still water had reached the elevation of 1084 feet above the level of the sea.

From this point the river turns about N.N.E., and, with the exception of minor bends, which in some parts are numerous, it maintains that course nearly for about six miles. At the end of this distance it reaches a small round lake, and here we terminated the measurement, finding it impossible to ascend in canoes, beyond a short distance, by any of the various streams which empty into it. The elevation of the surface of this lake, called Wahzuzke Lake, was calculated to be 1097 feet above the sea. The main branch above Wahzuzke Lake falls in on the north side, and its course, as far as we were able to follow it (which was chiefly done on foot), points upwards in a N.E. direction; it probably keeps nearly on that course to its source, which is supposed to be within a short distance of the head waters of the Petewahweh, as shewn on Bouchette's general map, taken from Mr. William Hawkins' exploration of 1837. From two to three miles above Wahzuzke Lake, the river was found to be still and deep, exceedingly serpentine and frequently blocked up at the turns by drift timber; but beyond that distance it became rapid, and was often impeded by beaver works and drift wood. At the end of about four or five miles, the valley contracts into a narrow precipitous gorge, and the river, which has dwindled to an insignificant brook, is broken by a succession of falls. The mouth of the main stream, on Wahzuzke Lake, where our measurement ceased, is in lat. 45° 38′ 20″ N., long. 79° 13′ 40″ W.

The following is a tabular arrangement of the levels of the Meganatawan river above the sea:—

Levels of the Meganatawan River.

	Distance. Miles.	*Rise.* Feet.	*Total Distance.* Miles.	*Height above the Sea.* Feet.	
Height of Lake Huron				578·00	Lake Huron.
Rise in the estuary of the river, where the current is very slight, estimated at 0.05 foot per mile,............	6	0·30			
—— in the river to the first small lake, viz :— Rapids, ... 1·80; Fall,............6·65; Fall, ... 5·26; Fall, ...15·50; Intermediate current, estimated at 0·50 ft p mile, say 2·00	4¾	31·21	10¾	609·51	Small Lake.
—— in the small lake, and above it to the junction of the south branch, or fork, the current being scarcely perceptible, estimated at 0·05 foot per mile........	2	0·10			
—— above the fork, where the current becomes strong, to the foot of a set of rapids and falls	¾	0·80			
—— in a set of violent rapids and falls, from smooth water below to smooth water above,............	1¼	44·81			
—— from the still water above the rapids and falls, to the still water below Island Lake, viz :— Fall,........... 2·40; Fall, ... 7·72; Fall, ...10·60; Intermediate current, estimated at 0·50 foot per mile, 0·75	1½	21·47			
—— on the surface of the smooth water which expands into Island Lake, to the junction of the main stream at the head of the lake, estimated at 0·05 foot per mile,	1½	0·07	17¾	676·76	Island Lake.

	Distance. Miles.	Rise. Feet.	Total Distance. Miles.	Height above the Sea. Feet.	
Rise above Island Lake to the upper fork, viz:—					
Rapid, ... 2·00					
Fall, ... 7·59					
Intermediate current, estimated at 0·40 foot per mile, 1·60					
	4	11·19			
—— on the open expanse of the river above the upper fork, the current being very slight, estimated at 0·06 foot per mile, ...	3½	0·21			
—— in three rapids, from smooth water at the foot of the lowest to smooth water at the head of the highest, viz:—					
1st rapid, ... 3·64					
2d rapid, ...20·56					
3d rapid, ... 2·00					
	1½	26·20			
—— above the three rapids to the outlet of Lake Wahwaskesh, estimated at 0·30 foot per mile, ...	1½	0·45	28¼	714·81	Wahwaskesh Lake.
—— on the surface of Wahwaskesh Lake, to the foot of the first fall above the lake, estimated at 0·05 ft. per mile,................	4	0·20			
—— from smooth water below to smooth water above the fall, ...		10·06			
—— from smooth above the fall, to still water below Maple Island, viz,—					
Fall, ...34·20					
Rapid, ... 1·00					
Falls and rapid, 21·08					
Rapids, ... 5·42					
Intermediate current, estimated at 0·50 foot per mile, 2·75					
	5½	64·45	37¾	789·52	Maple Island.

	Distance.	Rise.	Total Distance.	Height above the Sea.	
	Miles.	Feet.	Miles.	Feet.	
Rise from still water below Maple Island, to the foot of a succession of falls and rapids, viz:— Four small rapids 10·71 Rapids, ...13·09 Falls, ...10·71 Intermediate current, estimated at 0·50 foot per mile, 2·50	5	37·01			
—— from smooth water below a succession of falls and rapids, to smooth water at their head, with short intervals of smooth water between, ...	1½	49·95			
—— from smooth water above the last rapids to smooth water above the falls, at the lower end of Aumick Lake, viz:— Rapid, ... 0·70 Falls, ...20·39 Intermediate current, estimated at 0·40 foot per mile, 0·70	1¾	21·79	46	898·27	Aumick Lake.
—— on the surface of Aumick Lake, from the head of the falls to the entrance of the main stream, estimated at 0·05 foot per mile, ...	5¾	0·28			
—— from Aumick Lake to the junction of Distress River, viz:— Fall, ...10·60 Current below & above the fall, estimated at 0.35 foot per mile, say 0·97	2¾	11·57			
—— from the mouth of Distress River to the entrance of the main stream into the Shesheep Lake, the current being very slight,........	5½	0·27	60	910·39	Shesheep Lake

	Distance. Miles.	*Rise.* Feet.	*Total Distance.* Miles.	*Height above the Sea.* Feet.	
Rise from Shesheep Lake to the junction of a large tributary from the north, including a set of falls and rapids about half-a-mile below the tributary, viz :— Falls and rapids, 26·73 Current below and above, estimated at 0·50 ft. per mile, say .... 6·00	12¾	32·73			
—— from the mouth of the tributary, to the outlet of Doe Lake, viz :— Rapids, ... 4·00 Rapids, ... 3·16 Intermediate current, estimated at 0·50 foot per mile, 2·87	5¾	10·03	78½	953·15	Doe Lake.
—— from the outlet of Doe Lake to the foot of a set of falls and rapids, viz :— 1st rapid, ... 3·60 2d rapid, ... 20·10 Intermediate current, estimated at 0·50 foot per mile, 2·37	4¾	26·07			
—— from the smooth water below to the smooth water above a set of violent rapids and falls, ...	½	85·27			
—— from the smooth water above the last rapids to the exit of a suite of small lakes, viz. :— Rapids, ... 16·89 Current, above and below, estimated at 0·50 foot per mile, ... 2·25	4½	19·14	88¼	1083·63	Small lake.

		Distance.	Rise.	Total Distance.	Height above the Sea.	
		Miles.	Feet.	Miles.	Feet.	
Rise from exit of suite of small lakes, to the outlet of Wahzuzke Lake, viz:—						
1st rapid, ...	2·00					
2d rapid, ...	8·89					
Intermediate current, estimated at 0·42 ft. p.mile, say	2·75					
	——	6½	13·64			
—— on the surface of Wahzuzke Lake to the entrance of the main stream, estimated at 0·05 foot per mile, ...		1½	0·07	96½	1097·34	Wahzuzke Lake

The tributaries of the Maganatawan are very numerous; several of them are of considerable size and importance, and are used by the Indians as routes of communication to various parts of the interior. Those that we ascended are severally marked on the map as the Little Falls River, the Neighick, the Distress, and the Doe Rivers. The Little Falls River joins the main stream on the north side, about one mile below Maple Island. The upward course of the stream is nearly due north for about a mile, in which distance there is a succession of heavy falls; it then opens into a picturesque little lake, about a mile and three-quarters long, by about ten chains broad, lying nearly east and west, or at right angles to the course of the stream. At the eastern end of this lake, the creek comes in on the north side, and was followed on an almost due north course for about a mile and three-quarters further; we here reached the latitude 45° 44′ 19″.8 N., and stopped at another set of falls.

The Neighick falls into the main river on the south side of Aumick Lake, near its western end, flowing with a gentle currant through a marsh, for about thirty chains; above this it opens into a beautiful lake, bounded on all sides by lofty and picturesque hills, indented by deep marshy bays, and dotted here and there with small rocky islands. At the southern end of the lake, the stream comes in, after having flowed sluggishly through a vast marsh, bounded on each side by

hills. It was followed in an upward course S.S.W. for about three miles, all through marsh, but at that distance the valley becomes narrow, being not much more than ten or twelve chains wide, and the stream a little farther up begins to show some rapidity. But at this part we found ourselves obliged to turn back, in consequence of the impediments in the river. From the numerous remains of hunting and fishing apparatus observed on this stream, it appeared evident that it is much frequented by the Indians; from its position it must be one of the principal waters followed from Sahwanegah River, where a tribe is settled, to the trapping grounds in the interior, and to Lake Nipissing.

The Distress River joins on the north side, at the great northern elbow, about two miles and a-half above Aumick Lake, and about half way between this and Shesheep Lake. For many miles of its course it flows sluggishly through marsh or swamp, in a wide open valley, with low pine-clad hills on either side. The general bearing upwards is from N. by E. to N.N.E. for about seven miles in a straight line, reaching the latitude 45° 44′ 39″ N.; here it becomes rapid, and, at the time of our visit, was no further accessible for the canoes. During the freshets of spring, the stream is used as a communication to and from Lake Nipissing; the stream which forms the continuation of the route on the northern side of the water-shed flows into the French River, a short distance below the falls of the Chaudière.

Doe Lake is connected with the main river by a rapid stream, only about thirty chains long, which joins on the south side, at a considerable elbow, in lat. 45° 34′ 6″ N., long. 79° 27′ W. nearly. The lake is divided into two open expansions, connected by a narrow strait running transversely to the general course upwards; this is a little west of south, and the entire length in a straight line, is a little over five miles. The continuation of the principal stream comes in at the south-western extremity of the lake, and its upward course is a little south of west for from two to three miles in a straight line. In this distance it flows through an immense marsh, and then bending to the southward, it becomes rapid, and is occasionally broken by falls.

Like other parts of the country where rocks of the Laurentian age occupy the surface, the region of the Meganatawan and its tributaries contains much barren and rocky land, not likely to become of any great agricultural importance; but there are nevertheless many and extensive tracts, where the indigenous growth bespeaks a fertile soil, and the contour of the ground offers no serious impediment to culture and improvement. Pine, both red and white, abounds almost everywhere; and the facilities for the application of water-power to machinery are in most parts ample. The entrance to the estuary from Lake Huron, indicates only the most dreary sterility, but on ascending a few miles, patches of good land are observable, bearing maple, elm and other hard-wood trees, with a sprinkling of good-sized pine.

Between the estuary and Wahwaskesh Lake, flats of good hard-wood land occur in many parts, and they were especially observed on the great island formed by the splitting of the river into the two channels which have been mentioned. South of Maple Island also, much of the soil appears to be productive. At the north-west end of Aumick Lake, there is an extensive growth of maple, mixed with other hard-wood trees and good-sized pine, and to this locality the Indians annually resort to make their supply of maple sugar; but the best tract of all, so far as we had an opportunity of judging, is on the Doe River, from three to four miles above Doe Lake, where the land is tolerably level, and nearly all clothed with hard-wood. This hard-wood country appeared to me to extend northward, nearly all the way to the main river; but over the southern expansion of Doe Lake the hills are elevated and abrupt, and consequently less accessible than the rest of the area for the purposes of cultivation.

Tracts of hard-wood land extend still higher up the main stream than Doe River, and maple groves were by no means uncommon, so far as we followed its course. Above Wahzuzke Lake, there is a sugar bush, which appears to have been long a resort of the Indians, for the double purpose of trapping during the winter months, and making a supply of sugar to return with to their homes in the spring.

The greatest drawback to the settlement of the Meganatawan is its natural inaccessibility, and in this respect it contrasts very unfavorably with the Muskoka described in last year's Report. After leaving the estuary the river is frequently broken by long furious rapids, which at certain seasons are far too shallow to admit of being safely *run* downwards, and this necessarily involves long, tedious and often difficult portages, both ascending and descending. The Muskoka, on the other hand, rises by a repetition of heavy vertical or nearly vertical falls, which are easily obviated by portages not often exceeding a few chains. As in the early stages of settlement the course of the river is the route that would naturally be resorted to for intercommunication, it is to be feared that such serious obstacles will stand greatly in the way of the improvement that much of the country in the valley of the Meganatawan is susceptible of receiving.

Among the wild animals belonging to the region, deer appear to be in great abundance; while bears, beavers, otters and other smaller animals hunted for their fur are still in considerable quantity. The waters abound in fish of various species; brook or speckled trout, black and yellow bass, pickerel or pike, are to be found at one part or another, but the first of these appear to be peculiar to the higher portions of the main river and its tributaries.

Lake Nipissing.

The survey of Lake Nipissing was commenced at the point where the measurement of the French River ceased in the autumn of 1847, and was carried along the south coast to the eastern extremity of the lake, where it was joined with your survey from the Mattawa of 1845. Thence the northern coast was followed to the north-west angle of the lake, where we found ourselves compelled to abandon further measurement, the season, at the time we reached the place, being very far advanced, and the weather having become extremely inclement.

Longitudinally the great body of the lake lies as nearly as possible due east and west; the eastern end is open and exposed,

having only two groups of islands near the middle, while the western extremity is completely filled with islands, so that it is scarcely possible to distinguish them from the main land, without following the coast. Entering the lake from the French River, the nearest points on the north and south sides are only seven miles apart; but opening into deep bays further east, the lake expands to the breadth of twelve miles or upwards, and from the heads of the principal bays opposite to one another, measures eighteen miles.

The total length of our measured distance from east to west, or rather from the head of the south-east bay to the head of the north-west bay, was forty-one miles. The most southern part of the lake at the east end is in lat. 46° 7′ 45″ N., at the head of a long bay filled with islands, into which an important stream falls, described hereafter; the most northern, where another large tributary falls into a wide open bay, reaches lat. 46° 22′ 32″ N.; the eastern extremity is in longitude, by account, 79° 26′ W.; and the western in 80° 16′ W., nearly.

The principal streams crossed on our survey, which fall into Lake Nipissing are the Nahmanitigong, or Red Chalk River, the South River, the Little Mattawa or the Vases River, the Silver River, the Sturgeon River, and the stream falling in at the north-west angle, where we ceased our measurement. The first of these falls into the south-east bay; the next into the eastern bay; the Vases, at the east end of the lake, north of the east bay; Silver River, into the great north bay; the Sturgeon River, on the north side, almost directly north from the outlet of the French River; and the last, as before stated, at the north-west angle.

The south coast of Lake Nipissing, at the eastern end, is bold and exposed, the land rocky and barren, bearing chiefly a scanty growth of dwarf evergreens, among which there is a small scrubby tree, called by those familiar with the country *bastard spruce*, being the same plant which I have erroneously termed pitch pine in former Reports. This tree, in every instance where I have hitherto seen it, seems to select the very poorest spots of soil for its growth, or to cling by its tough and tenacious roots to the rents and seams of the naked rock.

The greater part of the north and east coasts is very low, descending to the water's edge in broad and low sand beaches; these, shelving out far into the lake, at a very small slope, render the approach to the shore, especially during westerly winds, a matter of considerable difficulty, even for small bark canoes; and as the mouths of the rivers and brooks, which are frequently deep a short distance back from the lake, are sometimes crossed by a broad bar of quicksand, some trouble is likewise experienced in following the beach on foot. West from the great north bay, where the Silver River comes in, the coast becomes more irregular, giving a deeply indented outline of alternating sharp rocky points and low sandy bays, while islands and small rocky islets stud the lake along the shore. The mouth of the Sturgeon River is an enormous marsh, and many extensive marshes occur at the heads of the principal bays, thence to the westward.

There are several Indian habitations on Lake Nipissing, all of which are on the north and east sides, and a Hudson's Bay Company's post is established on the Sturgeon River, about two miles above the entrance. At each of the inhabited places a small amount of cultivation has been attempted, which, judging from the samples of potatoes I saw, has not been altogether unsuccessful. The soil is for the most part light and sandy, but much of it of good quality, yielding good-sized hard-wood trees, mixed with pine. The high freshets of spring, according to Mr. Sauvé, the master of the post at Sturgeon River, are the most serious obstacles to cultivation, as it is not unfrequent at that time of the year, to have the water rising over the lower sills of his house, at least ten feet above the level of the river prevailing at the time we saw it in the end of October.

Cranberries are a great source of revenue to the Indians of Lake Nipissing; these growing in almost incredible quantities in the great tracts of marsh which surround the lake, are gathered during the fall of the year, and sold in barrels to the various traders of Lake Huron, many of whom come purposely to procure them. This large supply

of cranberries, together with furs of all kinds, and birch-bark canoes which are acknowledged to be the very best of their kind, both in build and material, is brought from Lake Nipissing to Lake Huron, and appears to have given to Indian craft in that remote region an impetus not often seen elsewhere. The people are for the most part tolerably cleanly, healthy, and thriving; and what is as good a mark as any, especially amongst Indians, they seem in general to be occupied. Their little huts are tidy and orderly, and have an air of comfort about them which I scarcely have witnessed amongst Indians anywhere else.

A group of islands called the Manitous, lying out near the middle of the lake, towards its east end, appear to contain some good hard-wood land; and on them, I was informed, the Indians annually make a considerable quantity of maple sugar. They also procure limestone from these islands for the purpose of building and making mortar.

Sugar is manufactured also on Iron Island, which lies about mid-way between Dukis' Point, one of the Indian settlements at the western extremity of the great north bay, and the French River. On Iron Island there are patches of good soil, although much of it is considerably encumbered with boulders.

The course of the Nahmanitigong or Red Chalk River, ascending from the south-east bay, is about S. E. by E. for about three miles; then presenting a set of falls, and making a short southerly bend, the general direction bears upwards nearly due east, for from six to seven miles; it then turns southerly, and keeps a nearly due south general course for about twelve miles in a straight line, making numerous and complicated meanders in the distance, which reaches lat. 45° 56′ 41″ N., where we stopped the exploration.

In the easterly bearing or lower part of the stream, there are nine sets of falls and rapids, giving a total rise, including an allowance of 0·50 foot per mile for current, of 135·07 feet above Lake Nipissing; in the southerly-bearing part there are seventeen sets, great and small, which with the same allowance for current amount to 292·42 feet more; placing

the highest part reached at an elevation of 427·49 feet above Lake Nipissing, or 1074·49 feet above the level of the sea. The tributaries of this river are mostly small, the volume of water on the main stream, where it is still, seeming scarcely to diminish at all, as far as it was followed. Between the various falls and rapids, the river is still and deep, and broad flats of good land extend on either side. The hills which bound the valley are frequently several miles apart, and bear a large proportion of hard-wood trees, mixed with pine.

The following is a tabular view of the rise on the Nahmanitigong River :—

Levels of the Nahmanitigong River above the Sea.

	Distance.	*Rise.*	*Total Dist.*	*Height above the Sea.*
	Miles.	Feet.	Miles.	Feet.
Height of Lake Nipissing,...........				647·00 Lake Nipissing.
Rise from the junction with Lake Nipissing to the smooth water below the lowest fall, estimated at 0·50 foot per mile, ...	3·55	1·78		
—— from the smooth water below to the smooth water above the fall, ..	0·01	7·59		
—— in smooth current above the fall,...	1·40	0·75		
—— in a rapid from smooth water below to smooth water above,....	0·74	27·78		
—— in current estimated at 0·50 ft. per mile, ...	0·40	0·20		
—— in a fall from smooth water below to smooth water above,....	0·05	43·62		
—— in current above, estimated at 0·50 foot per mile,....	0·40	0·20		

	Distance. Miles.		Rise. Feet.		Total Dist. Miles.	Height above the Sea. Feet.	
Rise in a fall from smooth water below to smooth water above,....	0·11		35·03				
—— in current, estimated at 0·50 ft. per mile, ...	0·51		0·26				
—— in a rapid from smooth water below to smooth water above,....	0·05		2·50				
—— in current estimated at 0·50 ft. per mile, ...	0·30		0·18				
—— in a rapid from smooth water below to smooth water above,....	0·04		1·50				
—— in current estimated at 0·50 ft. per mile, ...	0·40		0·20				
—— in a rapid from smooth water below to smooth water above, ...	0·10		7·58				
—— in a rapid above the last, from smooth water below to smooth water above,....	0·10		2·50				
—— in current, estimated at 0·50 ft. per mile, ...	0·24		0·13				
—— in a rapid from smooth water below to smooth water above,....	0·10		2·00				
—— in current, estimated at 0·50 ft. per mile, ...	2·54		1·27				
	——	11·04	——	135·07	11·04	782·07	Great Elbow.
—— in current and two small rapids: 1st rapid, 0·50; Current in 3·65 miles, 1·83; 2nd rapid, 0·70							
——	3·69		3·03				

	Distance. Miles.	Rise. Feet.	Total Dist. Miles.	Height above the Sea. Feet.
Rise in current estimated at the rate of 0·50 foot per mile, say	0·20	0·12		
—— in a rapid from smooth water below rapid to smooth water above fall: Rapid,.... 0·30 Fall,.....27·59 ——	0·12	27·89		
—— in current, estimated at 0·50 ft. per mile,.......	1·95	0·98		
—— in fall and rapids from smooth water below to smooth water above, ...	0·10	22·61		
—— in current estimated at 0·50 ft. per mile, say ...	0·70	0·36		
—— in a fall from smooth water below to smooth water above,....	0·01	18·30		
—— in current estimated at 0·50 ft. per mile, ...	2·10	1·05		
—— in falls and rapids from smooth water below to smooth water above, ...	0·12	6·76		
	—— 8·99	—— 81·10	20·03	863·17
—— in current estimated at 0·50 ft. per mile, ...	0·63	0·32		
—— in falls and rapids from smooth water below to smooth water above, ...	0·50	8·91		
—— in current, estimated at 0·50 ft. per mile, say....	1·40	0·75		

	Distance. Miles.	Rise. Feet.	Total Dist. Miles.	Height above the Sea. Feet.
Rise in a fall from smooth water below to smooth water above,....	0·40	8.81		
—— in current estimated at 0·50 ft. per mile, ...	1·88	0·94		
—— in a rapid from smooth water below to smooth water above,....	0·07	1·50		
—— in current, estimated at 0·50 ft. per mile, ...	0·31	0·16		
—— in falls from smooth water below to smooth water above,....	0·05	23·33		
—— in current estimated at 0·50 ft. per mile, ...	0·24	0 12		
—— in rapid from smooth water below to smooth water above,....	0·17	7·00		
—— in current, estimated at 0·50 ft. per mile, ...	0·43	0·22		
—— in fall and rapid from smooth water below to smooth water above, ...	0·40	43·79		
—— in current, estimated at 0·50 ft. per mile, say....	1·17	0·59		
—— in a rapid from smooth water below to smooth water above,....	0·04	1·00		
—— in current, estimated at 0·50 ft. per mile, say....	0·14	0·08		
—— in a fall from smooth water below to smooth water above,....	0·10	8·80		

	Distance. Miles.	Rise. Feet.	Total Dist. Miles.	Height above the Sea. Feet.	
—— in current, estimated at 0·50 ft. per mile, ...	2·43	1·22			
—— in succession of rapids and falls from smooth water below to smooth water above, ...	0·30	65·18			
—— in current above falls, where the measurement terminates along the course of the stream, which is very sinuous, and frequently jammed with drift-wood, ...	4·16	2·08			
—— in succession of falls, from smooth water below to smooth water above, ...	0·20	36·52			
	—— 15·02	—— 211·32	35·05	1074·49	Lat. 45° 56′ 41″ North.

The South River, which falls into the east bay by a fine cascade about thirty feet high, was ascended only a few hundred yards. Above the falls it is still and deep, carrying a breadth of about a chain.

The Vases, or Little Mattawa, called so as being the direct route to the branch of the Ottawa called the Mattawa, was ascended to the first portage, about three miles up the stream; but as it has already been described in your report of 1845, further mention of it here is perhaps unnecessary.

The Silver River falls into the great north bay with a tolerably swift current, and with a breadth at the exit of upwards of three chains. It contracts a little way up, and the course ascending is nearly due north for from a mile and a-half to two miles, where there are falls. I was informed by the Indians that above the falls it turns easterly, and at no great

distance opens out again into a series of lakes, fed by a multitude of small brooks, none of which are navigable for any considerable distance. There is said to be a portage to the lakes from the Indian village at the east point of the great north bay.

The Sturgeon is a very large river; at the Hudson's Bay post, where the current is very perceptible, the breadth is upwards of four chains, and there is a large body of water. It is said to proceed from Lake Temagamang, about half-a-degree of latitude due north from the post, and to be very rapid and difficult to navigate. It is used however as a route by the Hudson's Bay Company between Lake Nipissing and Lake Temiscamang, and is the most direct means of communication with the upper Ottawa on the route to Hudson's Bay.

The stream at the head of the north-west bay was not followed; it comes into the lake over a fall, above which there is a scarcely perceptible current, having a breadth of from twenty-five to thirty feet, the course bearing away to the westward.

DISTRIBUTION OF THE FORMATIONS.

Laurentian Series.

With the exception of a few small outlying patches of Lower Silurian strata on the islands of Lake Nipissing, the Laurentian series occupies the entire surface of the region explored during the season. The rocks of the lower part of the valley of the Maganatawan, below Wahwaskesh Lake, are fine-grained grey or reddish gneiss, with occasional layers of whitish quartzite and mica slate; the strike is for the most part at right angles to the course of the river, the dip varying from a little north of east to south-east. In some parts, the gneiss holds small pink and brownish garnets, and these were particularly observed at the falls below Island Lake, about half-way between the estuary and Wahwaskesh Lake. At the second falls above Wahwaskesh Lake, there are beds of greenish gneiss, apparently pyroxenic, interstratified with beds of red and grey gneiss, and with mica slate.

At Maple Island bands of white crystalline limestone occur, separated by gneissoid beds, some of which hold pyroxene giving them a green colour, with numerous small pink garnets. The run of the calcareous bands is nearly due north and south, with an easterly dip at a very high angle or occasionally vertical. They were traced to the southward, for about a mile and a-half from the main river, where the rock becomes concealed by dense vegetation; and to the northward they were found on the Little Falls River, coming out in large volume at the highest set of falls that we visited, a little over two miles due north from the most northerly point of Maple Island.

At the south end of Neighick Lake, the gneiss is very much shattered, and is penetrated by large veins of a very coarse-grained aggregate of quartz and feldspar. There are portions of a rock also at the south end of the same lake, of a mottled dark bottle-green and white, the constituents being chiefly dark green pyroxene and white quartz, sprinkled occasionally with small pink garnets. The rocks seen on the Distress River, where the rapids begin, appear to dip south-westerly, but on the main river, a short distance above the junction of the same stream, where the strata are very regular, it is N. 70° W. $<30°$. About three miles higher up the main river, on Shesheep Lake, where bold and nearly vertical cliffs rise on the south side, the strata seem to dip to the south-west.

At Doe Lake, the strata are very much disturbed, and shew frequent folds and contortions, but the general run of the ridges and strike of the strata tend east and west. The rock at the strait, which is micaceous and very fine grained, shews a dip S. 8° E. $<33°$. Veins composed of quartz and feldspar are of frequent occurrence; some are of large size and very coarse grained, and they run for the most part parallel, or nearly so, with the strike of the rocks.

Above the junction of Doe River the rocks at the rapids were usually more or less garnetiferous, and presented southerly and easterly dips. At Wahzuzke Lake the dip was sometimes a little to the west, at others a little to the east of south; but

the general trend of the hills and ridges being nearly N.E. and S.W., it is possible the strike of the strata corresponds, and that the average dip is S.E.

On the south coast of Lake Nipissing, between the French River and the Nahmanitigong, the gneiss, which is usually of a red color, dips southerly, often at an angle under fifteen degrees; while further in the interior, as seen on the banks of the upper reaches of the Nahmanitigong, where the rock is almost invariably garnetiferous, it is nearly flat, and that attitude appears to be more or less maintained, as high up that river as our survey extended.

The gneiss of the south-east coast, between Nahmanitigong and South Rivers, is everywhere highly disturbed, being intersected in all directions by intrusions of trap, and frequently cut by quartzose or feldspathic veins. On the islands in the eastern bay, crystalline limestone occurs; it also is very much disturbed by trap, and it lies in such confusion that the bedding cannot readily be distinguished. The general run appears to be about E.S.E, and W.N.W., but the dip could not be determined with any degree of satisfaction. The character of the trap is various; it occurs sometimes as a very fine grained greenstone; at others, it is of a jaspery texture and a red or pinkish color, and it occasionally assumes a concretionary form, presenting dark green pyroxene in a calcareous matrix, with large scales of black mica and iron pyrites irregularly disseminated through the mass. Patches and small masses holding grains and specks of magnetic iron ore were found both in the gneiss and in the trap.

Where the rock comes out at the points on the eastern shore, it usually exhibits finely laminated layers of deep red and dark grey gneiss, the general run of which tends towards N.W. and S. E. dipping northerly, but making several undulations. The north and north-east sides of the most western of the Manitou Islands shew great disturbance, and display masses of trap mixed up with and penetrating the gneiss. At Iron Island, crystalline limestone occurs, interstratified with, and cut across by trap, the general strike of the beds being very nearly W.N.W. and E.S.E. with a dip

to the northward. On the north side of Iron Island, apparently overlying the great mass of crystalline limestone, the strata are mostly of a red or green rock, weathering black, alternating with pale red jaspery trap and thin white calcareous beds or veins, all of which are cut across, nearly at right angles, by trap. Beds or intrusions of trap, assuming the concretionary character also occur here.

Small masses of specular iron ore are common to most of the rock in the island, and in the crystalline limestone there is a very great display of it. For a breadth of about forty yards along the cliff on the east side, the rock holds masses of the ore of various sizes, sometimes running in strings of an inch thick or upwards, and at other times accumulating in huge lumps some of which probably weigh over half-a-ton. The beach near the outcrop is strewed with masses of all sizes, from great boulders, weighing several hundred pounds, to small rounded pebbles, not bigger than marbles. The limestone with which the iron ore is associated is frequently cavernous, and the crevices and smaller fissures are thickly lined with crystals of blue fluor-spar and red sulphate of barytes or cockscomb-spar.

Crystalline limestone crops out on the opposite or west side of the island, and judging by the strike of the north-side, it must correspond with that holding the iron ore on the east. The same minerals were found disseminated through the rock and strewed upon the beach. At the extreme south-west point of the island the rock is again crystalline limestone, and a long beach running out from it to the westward, is perfectly covered with boulders of specular iron ore. Iron ore occurs also at the south-east point of the island, although not in such great abundance, and only in detached masses strewed upon the beach.

On the north shore, from Dukis' Point westward, and on the islands off that part of the coast, the gneiss is mostly of a red color, and contains magnetic iron ore in patches and small masses, sometimes thickly disseminated both in the strata and the veins cutting them. A very fine-grained dark blue slate was seen also, in large loose irregular blocks along the south

shore of the north-west bay, which appeared to be of a character rendering it fit for whetstones. The strike of the gneiss at the north-west indentation of the lake corresponds with that of Iron Island, being nearly W. N. W. and E. S. E., with a dip at a high angle to the northward.

Fossiliferous Rocks.

A small exposure of fossiliferous strata was found in the most western island of the Manitou Group, resting unconformably on the gneiss and trap, which constitute the larger portion of the island; the section, which is not over six feet thick altogether, is based upon a bed of silicious limestone holding *Orthoceras*, with a few other obscure fossils and small angular fragments of the altered rock on which it rests. Over the silicious bed are alternations of blue and grey limestone and shale, holding numerous fossils, among which are orthoceratites and shells both univalve and bivalve, but all too obscurely defined to admit of correct identification; the orthoceratites, which are very numerous in all the beds, strongly resemble the *Ormoceras tenuifilum* of Hall, given by that author as a characteristic species of the Black River formation. These beds occur on the south west end of the island, and shew a gentle dip to the S. W.

On the west side of Iron Island, beds of red and grey sandstone rest unconformably on gneiss and crystalline limestone, dipping at the north end of the exposure, S. 30° W. $<4°$, and at the south end S. 75° W. $<3°$ to 5°. The lowest beds of the sandstone are red, with small round green spots occasionally dotted over the surface; the sandstones are coarse-grained and the beds vary in thickness from six inches to two feet. The upper beds are yellowish-grey and sometimes whitish, and occasionally appear to be slightly calcareous; they are mostly of coarse grain, at times becoming a fine conglomerate. Small sub-spherical concretions are common to the upper beds, and on one occasion an impression resembling the obscure cast of an orthoceratite was observed on an exposed surface. Some of the beds are probably well adapted for grindstones.

The greatest thickness exposed on the beach is from ten to twelve feet, but the side of the hill facing the west, which

was about seventy feet or upwards over the level of the lake, is chiefly of sandstone, some of which may be additional strata. Large angular masses of fossiliferous limestone are strewed on the beach, having been removed apparently no great distance from their parent beds; they probably occupy a portion of the bottom of the lake. The character of the fossils in those masses appeared to be of the Chazy age.

Drift.

Stratified clay was found on the banks of the Meganatawan at several parts, the highest well exposed section being above the second long rapids, east of Doe Lake. The color of the clay is a brownish-drab; it is very tenacious and gives no effervescence with acids. The highest exposure of clay on the Meganatawan was calculated to be a little upwards of a thousand feet above the level of the sea.

A fine strongly tenacious clay occurs on the Nahmanitigong, near the main elbow, where the upward course of the river turns to the south; the colour of the clay is chiefly a pale drab or buff, but bands of reddish clay are interstratified, and some of pale blue overlie the whole. Associated with the drab coloured clay are numerous small sub-spherical calcareous concretions, which were suspected to be formed round a nucleus of something organic, but no remains were detected. The clay enclosing the concretions appeared to be purely argillaceous, and gave no effervesence with an acid. The section was estimated to be 710 feet above the level of the sea. The clays of the interior are usually overlaid by a deposit of coarse yellow sand.

Among the boulders on Lake Nipissing, many were observed to be of a slate conglomerate, and they were frequently of very great size; in their aspect and general character these have a very strong resemblance to the slate conglomerate of the Huronian series, from which in all probability, they are derived.

I have the honour to be,

Sir,

Your most obedient servant,

ALEX. MURRAY,

Assistant Provincial Geologist.

REPORT

FOR THE YEAR 1855,

OF

ALEXANDER MURRAY, Esq., ASSISTANT PROVINCIAL GEOLOGIST,

ADDRESSED TO

SIR WILLIAM E. LOGAN, PROVINCIAL GEOLOGIST.

WOODSTOCK, 1*st* *March*, 1856.

SIR,

Previous to your departure as one of the special commissioners representing Canada at the Great Industrial Exhibition of Paris, you were pleased to suggest that I should again visit certain districts of the western portion of the Province, hitherto only partially examined, to trace out the boundaries of the several geological formations, in as minute detail as circumstances would permit.

In accordance with this suggestion, after having visited a few parts east of Toronto to examine certain sections of rock strata which I had not previously seen, near the junction of the Trenton limestone with the Utica slate, I proceeded to make an excursion through portions of the Huron and Western Districts, accompanied by Professor James Hall, of New York, whose intimate knowledge of the palæontology and mineral character of the corresponding strata in the neighboring state was of the greatest assistance in the examination, and enabled us definitely to determine the geological age of the highest of the ancient rocks of Western Canada.

Upon my return from this excursion, I made preparations for another expedition to Lake Nipissing, in order to complete the survey of that lake, commenced the previous season. Having furnished myself with the necessary supplies at Toronto, I proceeded to Shi-bah-ah-nah-ning on the north shore of Lake Huron, where I had already bespoken a party of Indians to meet me. There being no established mode of conveyance at the time, I was about to cross Lake Huron to Shi-bah-ah-nah-ning, I was spared much time and inconvenience through the kind assistance of the Honble. Mr. Killaly, who directed that the Iroquois yacht, then employed by Mr. Robinson, the engineer in charge of the construction of light houses, should be put at my disposal to take me to my destination, which was done accordingly.

The survey of Lake Nipissing was commenced at its outlet into the French River, above the Chaudière Falls, and thence carried around the west coast, closely following all the sinuosities, to the point at the north-west extremity, where the measurement terminated in 1854; it embraced at the same time as much as possible within that distance, all the larger islands and prominent topographical features which characterize the borders of the lake. Finally, after ascending a large tributary of the French River, of which a sketch was taken, the season's work was terminated by making a measurement of the eastern outlet of the French River into Lake Huron.

FOSSILIFEROUS ROCKS OF WESTERN CANADA.

Trenton Limestone and Utica Slate.

The geological features of the western country, as described in former Reports, although generally correct, still require a certain amount of modification, where the detail has not hitherto been minutely followed out. A section occurs near the shore of Lake Ontario, about a mile south of the village of Oshawa, in the township of Whitby, by the road leading to Oshawa harbour, in which are displayed black bituminous shales holding *Triarthus Beckii*, *Orthoceras*, and other characteristic fossils of the Utica slates; the dip of the shales is

nearly N. $<5^{o}$., and passing below them there are beds of blue limestone, with the fossils peculiar to the Trenton formation.

Again, in the quarry recently opened for building material by the Grand Trunk Railroad contractor, at Bowmanville, the upper beds of limestone are overlaid by similar black shales, with the same Utica slate fossils, shewing a strike between the two places nearly north-east and south-west, with a north-westerly dip. As the general run of the formations between Georgian Bay and Lake Ontario is from north-west to south-east, at nearly a right angle to the strike of the exposures just mentioned, with a contrary dip, it is clear that an undulation occurs, forming a small synclinal to the north of these, the opposite and southward-dipping side of which is probably near the elevated ridge, south of Scugog Lake. As frequently remarked in previous Reports, however, the enormous accumulation of drift which here conceals the older rocks, renders it impossible to follow the outcrops with more than a fair approximation to the reality.

Hamilton and Portage and Chemung Groups.

In my Reports of 1848-49, and 1850-51, the black bituminous shales which were observed at Kettle Point, on Lake Huron, and at the flour mills, on the Sydenham River, are described under the head of the Hamilton formation. The shales in those instances are either altogether destitute of organic remains, or hold only forms of plants and obscure shells of species not then described, and being in each case immediately underlaid by beds of limestone, in which *Spirifer mucronatus* and other characteristic fossils of the Hamilton group are abundant, it was inferred that the shales belonged to the group. Mr. Hall, however, on seeing the section at Kettle Point, expressed it as his opinion that the rocks were the lowest measures of the Portage and Chemung group, and this opinion was further confirmed by our subsequently finding a nearly complete section of the Hamilton group on the banks of some of the tributaries of the River Sable, (south), shortly

afterwards, on the twenty-fifth lot of the third range of Bosanquet. On the banks of a small tributary of the Sable, the following section was measured in ascending order:—

	feet.
1. A slope or talus over the stream	25
2. Grey calcareous shales with *Spirifer mucronatus* and numerous fossils	4
3. Bed of compact encrinal limestone	2
4. Soft shales, thinly laminated next the limestone, filled with fossils, among which *Cystiphyllum cylindricum* (Hall's Rep. 4th Dist. N. Y.) is very abundant; the upper part decomposes into a clay, and fossils are found in the decomposed edges	20
5. Decomposed shale or clay, not well exposed	80
6. Grey encrinal limestone, weathering into small lenticular fragments, and holding bivalve shells, corals and encrinites	2
	133

At Jones' mill, on the third lot, south boundary of Bosanquet, on the bank of a small tributary of the Sable, another section is exposed, which in ascending order, is as follows:—

	FEET.
1. Brownish grey-weathering shales, holding *Spirifer mucronatus* in great abundance, and a few other bivalves and corals	25
2. Encrinal limestone	2
3. Decomposing shale, with *Cystiphyllum*,	3
	30

At Austin's mill, on the fourth lot of the first range of Bosanquet, on another small creek, there is a corresponding section, where the encrinal limestone which forms the uppermost layers of the exposed strata, is about five feet thick. Below the encrinal limestone, the shales are characterized as at the other places by a profusion of *Spirifer mucronatus;* and in the bed of the creek at a level probably about fifty or sixty feet lower than the upper limestone bed, there is a band of hard and compact arenaceous limestone, about seven inches thick, underlaid by black shales holding *Atrypa*, *Leptæna* and *Chonetes*.

The overlying bituminous shales of the Portage and Cheming group were found at two localities not observed previously; one in the bed of a stream supposed to be the north branch

of Bear Creek, near Kingston's mills, on the seventh lot of the third range of Warwick; and the other at Branon's mills, on the twentieth lot of the seventh range of Brooke, in the bed of the east branch of Bear Creek. In each of these instances the shales are characterized by spherical concretionary calcareous nodules and masses, as at Kettle Point; but with the exception of some rather obscure scales of fish, which were found at the exposure in Warwick, no fossils were discovered at either place. The debris of the Hamilton shales with *Spirifer mucronatus*, *Atrypa* and corals, were found abundantly among the drift; and large masses of the encrinal limestone lay at the bottom of the creeks, and in the surrounding country.

In my Report of 1848-49, the clays of the township of Plymton, on the shore of Lake Huron, are described under the head of Drift, and the fossils in the limestone pebbles are represented as those peculiar to the Corniferous formation; a comparison of the Plympton fossils with the collection of the present year however tends to shew that the clays and organic remains in the limestone are derived from the ruins of the decomposing shale of the Hamilton group, while the pebbles of quartz, granite, and altered rocks, are portions of the lake drift. It appears highly probable that a large portion of the clay country in the neighbourhood of Chatham, and at the mouth of the Thames, takes its argillaceous character from the same source, and that the limestone formerly mentioned, but not yet examined, which occurs in Harwich, belongs to one of the beds of encrinal limestone of the Hamilton formation.

The result of the evidence thus obtained leads to the conclusion that the trough or belt of the Hamilton formation, running across the peninsula, is considerably broader than previously represented, and that it contains near its centre, one and probably two out-lying patches of the superior formation; because if it be admitted (which is most probably the case) that the asphaltic deposits and the petroleum springs of Bear Creek in Enniskillen on the one hand, and the petroleum springs of the Thames in Mosa on the other, take their origin from the

bituminous shales of the Portage and Chemung group, the lower formation protrudes through, and probably divides the shales at Smith's mills, on the Sydenham River, in the township of Euphemia, as described in my Report of 1850-51, where the prevailing fossil is *Spirifer mucronatus*, which at the time I wrote that Report, I supposed to be identical with a very similar species, peculiar to the Corniferous limestone.

The absence of exposures of the older strata, in consequence of the great thickness of the drift deposits through the western region, renders it very difficult to give a perfectly accurate outline of the various boundaries of the formations; judging however from the facts above stated, together with others previously mentioned in other Reports, it is probable that the eastern outcrop of the Hamilton formation commences on Lake Huron, near the town line, between Stephen and Hay, and then runs southerly, parallel to the Sable River, through McGillivray, Williams, Adelaide and Caradoc; thence bending easterly, it crosses the Thames near Munsey Town, and afterwards holds an easterly course towards Long Point, parallel with Lake Erie. The western outcrop may be supposed also, from data given in former Reports respecting the distribution of the Corniferous limestone, to run across from Lake St. Clair, somewhere near the mouth of the Thames, through East Tilbury and Raleigh, towards the Rondeau on Lake Erie.

Drift.

It was frequently remarked in our progress through the townships between Woodstock and Goderich, that large angular unworn masses of sandstone, unlike in general mineral character to any recognized strata belonging to the western region, and destitute of organic remains, were strewed over the surface of the ground, or deposited in the superficial drift. In a few instances, particularly in the neighbourhood of the town of Stratford, some obscure markings resembling *Scolithus* were observed in a rather finely granular sandstone, but this was the only resemblance to anything connected with organic forms perceived in any of the sandstone masses. Occasionally

the masses were hard, compact and quartzose, but more frequently granular, sometimes coarsely so, approaching a conglomerate, and sometimes they were considerably calcareous.

In some instances these masses are so large as to have led to the belief that they constituted a part of the solid strata, and they have been quarried as such for building purposes. This was particularly the case on the farm of Mr. Alexander Gardner, on the twenty-third lot of the seventh range of Goderich, where it was represented to me that there was a fine quarry of freestone opened and being worked. On examining the spot indicated, the quarry proved to be an accumulation of large angular masses of a grey calcareous coarse-grained sandstone, holding rounded pebbles of trap and limestone, and a few very small ones of red jasper. The sandstone was imbedded in a bank of brownish clay, beneath which a band of yellow clay was seen to pass, well exposed at the bottom of a little rivulet immediately below the opening. The bank containing the masses runs about north-east and south-west, facing north-west; and the masses themselves point a little westward of north-west. The size of the largest masses could not be ascertained, as they were deeply imbedded in the clay; but the thickness of one stratum was about three feet, and the edges were exposed along the run of the bank for some twenty or thirty feet.

Similar masses have frequently been observed at several parts of the county of Oxford, and, unlike the drifted metamorphic boulders with which they are associated, they invariably shew sharp unworn edges, as if transported from no very remote locality. Whether these sandstone masses are debris of a higher or lower formation than the Corniferous limestone on which they rest, is very difficult if not impossible to determine; but the probability seems to be that they are derived either from the sandstone of the Portage and Chemung group, which has a wide spread in the State of Michigan, or from the representative of the Oriskany sandstone, which is recognizable in some parts of Canada.

The occurrence of a band of quartzose sandstone between the gypsiferous rocks and the Corniferous limestone, in the

township of Cayuga, on the Grand River, is mentioned in my Report for 1843-44; this sandstone, from its position, may be assumed as corresponding to the Oriskany sandstone of New York, and it seems highly probable that it is from portions of the continuation of this band that the masses take their origin. It is true that the mineral character of the exposure at Cayuga is different from that usual in the masses of the drift, but all the evidence tends to shew that the drift has proceeded from north-west to south-east, and it is not unreasonable to suppose that the mineral character of the band may have materially changed in its course from Lake Erie to Lake Huron, and that at the latter place it may have given origin to this remarkable portion of the drift. The close proximity of a portion of the upper members of the Onandaga salt group at Goderich to the masses of sandstone upon Gardner's farm, is likewise in favor of the assumption that the latter took their origin from the stratigraphical position indicated; and the fact that a large portion of the smaller drift over the whole region is the debris of the gypsiferous rocks, would be a farther support to this view.

The course of the currents which have borne along this drift appears to be indicated not only by the character of the material deposited, as clay, gravel, or boulders, but by the bearing of the ice-grooves and scratches upon the smooth surface of the solid rock. The pebbles and boulders of metamorphic rocks which abound in the gravel and clay deposits, and are numerously scattered over the surface, are clearly derived from the Laurentian and Huronian formations on the north shore of Lake Huron; while the fossils and mineral character of the limestone pebbles, which constitute the greater part of the gravel, are as evidently those of the gypsiferous or corniferous limestones. In several parts, where the solid strata are exposed, and particularly in the vicinity of St. Mary in the township of Blanchard, on the Thames, the upper surface of the highest bed of limestone is smoothly polished, and being stained irregularly with red and yellow, with occasional lines of white, it assumes the appearance in many parts of variegated marble; this surface is invariably marked

by grooves and scratches, all bearing northwest and south-east nearly.

EXPLORATION OF LAKE NIPISSING AND THE FRENCH RIVER. GEOGRAPHICAL CHARACTERISTICS.

Lake Nipissing.

Above the Chaudière Falls, the lower portion of Lake Nipissing takes a general bearing north-east, with an average breadth of from one to two miles, till it expands to the east and west, at the distance of about eight miles into the main body. The west side of this southern arm is deeply indented by a succession of long narrow bays, lying for the most part nearly east and west, and crowds of islands are scattered along the channels and off the shores. From the most southern of these bays, which falls back to the westward for upwards of seven miles, there are two outlets in addition to the one at the Chaudière, the waters of which appear to unite in their course to the southward, and flow in a single stream into the French River, above the Rapide du Pin, falling in a fine cascade of about twenty feet, close to the junction.

The southern shore of the main body of the Lake trends in general very nearly due east and west, forming in the last twenty miles of the west end, the south side of a great western arm, which alternately contracts into narrow straits, in some cases only a few chains wide, and opens again into wide expanses, generally crowded with islands. Measuring from the north-east end of the southern arm to the extreme end of the great western bay, the distance is somewhat over thirty-two miles, and from the extreme east end of the lake to the same place, the total length is a little over fifty-three miles, the western extremity reaching longitude by account 80° 30′ 54″ W. This great western bay was called Bear Bay, and between it and the north-west arm, where the survey terminated in 1854, there are two other large westerly bays, divided by a bold rocky promontory jutting out nearly due east, with a multitude of islands in continuation of the

strike, stretching far into the lake. In addition to these main features the whole coast is deeply indented by a succession of marshy bays and coves, separated by bold rocky points, and a number of small streams add their tribute to the waters of the lake.

The general aspect of the western end of Lake Nipissing is bleak and desolate in the extreme. In many parts the coast is entirely bare and barren, and in no instance does the soil afford a better quality of forest timber than a scanty growth of red pine. Vast marshes, overgrown with tall reeds or wild rice, stretch far into the interior, beyond the bays or along the mouths of the tributaries, affording shelter to incredible numbers of wild fowl. Were drainage practicable, these marshes might become available as grass land, but being scarcely at any part above the level of the lake, they are not readily susceptible of artificial improvement.

While the coast presents this wild and desolate appearance, there are many spots not very remote from it where the character of the country is much less forbidding. On the banks of several of the tributaries of this end, all of which are small however, and only accessible to canoes for a short distance, there are good flats of land, in some cases yielding hard-wood mixed with large-sized white pine; and spots repeatedly occur between the rocky ridges which might be rendered available for the purposes of cultivation. About two miles and a-half up a stream which falls in on the south side, near the entrance to the great west bay, the flats extend over a considerable area, and many very large trees of white pine were observed on them, together with maple, elm and birch. Red pine abounds wherever there is soil enough to support a growth at all; and in many parts, especially in the vicinity of the large western bays, it is of good size, straight, and apparently sound.

Like the coast of the main land, the islands for the most part, are rocky, barren and worthless; but this is not without exceptions. As an example, I observed on this occasion, on a second visit to Iron Island, that a large proportion of it, especially towards the southern end, has an excellent soil,

yielding a stout growth of maple, basswood, elm and birch, and provided the surface be not too stony, there can be no doubt it is capable of being converted into good farm land. The superior quality of the soil of this island is doubtless due to the calcareous nature of the rock beneath, and this good soil, together with the specular iron ore and its associated fluor-spar, as well as the sandstone and limestone mentioned in last year's Report, seem to indicate the position as one worthy of attention when settlement shall at some future time reach the shores of the lake.

Among the various wild animals which inhabit the country surrounding the lake, I more especially remarked the presence of numerous bears and deer. Reindeer were by no means uncommon, while wild fowl of many descriptions flock in myriads, at certain seasons, to the marshes. The fish of the lake are also very abundant, of unusually large size and excellent quality: the varieties consisting of white fish, maskinongé, pike, bass, pickerel and sturgeon.

As observed in my Report of last year, the Indians of Lake Nipissing derive a very considerable profit from the sale of cranberries, which grow in vast quantities on the numerous marshes; but as it is probable that not one-tenth part of the whole area where the fruit abounds is ever visited by the few scattered families inhabiting the country, it appears to me that the produce might be turned to much greater account, and become a tolerably good source of recompense to a settlement. I was informed by an Indian that he and his family, which consisted of his wife and two small children, could easily gather from four to five barrels of cranberries in a day, for which they were paid, on delivery at Shi-bah-ah-nah-ning, at the rate of $5 the barrel; and that the only difficulty which they had in making the trade a very profitable one, was the small amount their canoes were capable of conveying at a time, together with the shortness of the season previous to the formation of the ice.

The tributaries which fall into this part of Lake Nipissing, on the south side and western end, are numerous, but all small, none of them being navigable for a canoe except for very short

distances beyond their lowest rapids. An exception is to be made of the river at the head of the north-west arm, which was ascended for several miles.

The longest and most important of the tributaries are the one at the north-west arm, already mentioned; one falling into the middle west bay; one which comes in at the northern head of Bear Bay, and another falling in on the south side, at the entrance to Bear Bay. The first three of these, as well as all the minor creeks of the west end, run nearly parallel to each other, their downward bearing being about E.S.E.; the last one, and those on the south side generally, flow in the contrary direction, from east to west, nearly parallel with the shore of the lake.

A large tributary was ascended which joins the French River on the east side, about three-quarters of a mile below the Chaudière Falls. It is connected with the main river by a narrow reach of still water, extending from east to west about two miles, and into this the stream runs over a set of falls and rapids, giving a rise to the position of the still water above them of from twenty to thirty feet. The general upward course of the river from the mouth is a little south of east for about twelve miles, making but slight deviations within that distance from a straight line. The river then expands into a small lake, from which the bearing is nearly south-east, traversing successively two large lakes, lying obliquely across the connecting stream. The longitudinal bearing of each of these lakes is nearly due east and west, and the river falls into the upper one at the north-east end, but reduced to a mere brook. It proved impassable beyond about a mile up, being completely obstructed by drift-timber and beaver works; its course was about N. E.

Above the lowest falls, the valley of the stream is wide and marshy, being bounded on either side by rugged rocky land, overgrown with pine, hemlock, and other evergreens, and the river is usually still, wide, and deep all the way up to the lowest of the series of lakes, except in two places where there are falls and rapids. The country surrounding the lakes becomes more elevated, rising in hills of from 200 to 300 feet

high, while the valley of the connecting stream is narrow and sometimes precipitous. The character of the timber, advancing upwards, indicated a gradual improvement in the quality of the soil, the lower parts being generally clothed with an indifferent growth of the various firs, while the hills around the lakes were covered principally with hard-wood; and it was observed here, as it had been in many other parts previously, that hemlock takes an intermediate position between the two. I have indeed so frequently had occasion to observe this intermediate position of the hemlock, that I never now meet with it without feeling assured there is at a somewhat higher level, a growth of hard-wood, usually mixed with large white pine. But notwithstanding that the soil is evidently of better quality in the interior, much of the surface is too rugged and broken to be recommended for a settlement, except it be as auxiliary to the lumber trade, which may probably extend to that region at some future time.

South Channel of the French River.

Between two and three miles above the Grand Recollet Fall, in the north channel, the French River expands into a broad area of still water, where numerous large islands intercept the view, and form a set of narrow complicated channels, which unite in a single stream about three miles to the southward. The most eastern of these channels, which was the one we followed, is about six miles from the Grand Recollet, and after making a course due south for the three miles mentioned, to a set of falls corresponding with the Grand Recollet, it turns abruptly to the west; the water flows sluggishly on in that direction, almost quite parallel with the north channel, for a little over thirteen miles, when making a slight bend to the north-west, it probably rejoins the main river a little above the middle outlet. The eastern outlet leaves the south channel at the north-westerly bend, and with a course due south, for a little over two miles, after expanding into a lake of considerable extent, filled with little islands, it falls into Lake Huron, over a set

of small contracted rapids, at the head of a long narrow bay, in lat. 45° 56′ 56″ N., and long. 80° 46′ 20″ W. nearly.

The south channel of the French River, in most of its characteristics, is a perfect counterpart of the north channel. Bounded on either side by lofty and precipitous rocks, in general but sparingly clad with small evergreens and bushes, there is little available land near the banks, while for some distance back the country is arranged in broken rocky parallel ridges, with narrow valleys between. Within these valleys there are occasional spots of good hard-wood, usually mixed with pine; and to such spots, where the maple is sufficiently abundant, the Indians resort in the spring to make sugar.

Only two streams of any importance fall into the south channel, one joining from the eastward, immediately below the falls at the upper end, and another flowing from the south, which joins the channel about a mile and a-half further down. The first of these appears to be a large river, and I was informed by an Indian that a canoe route by it was known, leading to the waters of the Meganatawan River. The other stream is also navigable for canoes for some distance up, where it flows through a great marsh, bounded on either hand by low rocky hills. But I should suppose, judging from its size near the mouth, that it must shrink into an insignificant brook where it first becomes rapid.

DISTRIBUTION OF THE ROCKS.

Laurentian Series.

With the exception of the small outlying patches of Lower Silurian strata, indicated in last year's Report as occuring on the Manitou Islands, and on Iron Island in Lake Nipissing, the whole region, as far as I have hitherto explored, is occupied by the Laurentian formation, consisting of red and grey gneiss, micaceous and hornblendic schists, quartzite, and crystalline limestone, the latter portion of the series having been observed at two localities only, namely in Iron Island near the middle of Lake Nipissing, and in the islands in the east bay, at

the extreme eastern end of the same lake. The strata are everywhere more or less contorted, in many places exhibiting sharp and complicated corrugations in the cliffs and precipices, and they are intersected by quartzo-feldspathic and quartz veins.

In their general arrangement throughout the country examined, the rocks appear to form a series of ridges, ranging N. E. and S. W., and usually inclining to the south-east; but at many parts around the outlets of Lake Nipissing the stratification is horizontal, and on the islands and promontories at the western end of the lake, the strike seems to turn about W.N.W. and E.S.E., with a N.N.E dip. The attitude and position of the crystalline limestone with its associated iron ore, and other minerals, on Iron Island, seem also to indicate a fold in the strata, in correspondence with this change in the general run, but the calcareous exposures on the lake are too small and too far apart to lead to any definite conclusion as to the general distribution of the rock.

The gneiss, in the western part of Lake Nipissing, both on the south and on the north side, but particularly on the latter, is for the most part red or of a reddish-grey, and is frequently characterised by patches and crystals of magnetic iron ore, which occurs also in the intersecting feldspathic veins. Small pink garnets occasionally characterise the micaceous and hornblendic slates which are extensively developed on the channels of the French River, but were rarely met with on Lake Nipissing. The quartzo-feldspathic veins, although all composed of the same constituent minerals, vary a good deal in certain other respects, some being very coarse, with large tabular crystals of red feldspar, while others are very fine in the grain, and very compact; it was observed that the fine-grained veins, in most cases, cut the coarser ones, and that both were frequently intersected by veins of white quartz.

At the Grand Recollet Fall, in the north channel of the French River, and in the south channel, about two miles south-east from them, the rock is of a brick-red color, without any distinguishable lines or layers of stratification; it was supposed to be an intrusive syenite, and with a general breadth

of from one to two miles, its course appeared to be N. N. W. and S. S. E.* The dip of the gneiss, which below the Grand Recollet Fall points generally to the south-eastward, changes above the fall, and becomes south-westerly; but higher up the river, above the junction of the several channels, notwithstanding the numerous folds and twists which the rocks present, the general strike of the ridges is resumed, and the prevalent dip is to the south-east.

The curious and complicated distribution of land and water on the French River and the western end of Lake Nipissing, as represented on the topographical plan accompanying this Report, is probably attributable in some measure to these and other similar facts of physical structure, and may afford an approximate index to the general geological arrangement, which may be ascertained when the relations of the several parts of the formation are more fully investigated and better understood. In the meantime, with the exception of the calcareous portion, which is but sparingly developed in this region, the different parts of the formation are so much alike in mineral character and condition, that it is very difficult to recognize any two exposures as equivalent to one another, if they are at all remotely apart.

Although magnetic iron ore is abundantly disseminated in patches and crystals through the gneissoid rocks of Lake

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* This brick-red rock and that mentioned by Mr. Murray in his Report for 1853 as found on the Muskoka and Petewahweh, particularly on the latter, from Cedar Lake downwards, appear to resemble some of the harder kinds of the *laterite* rock of the East Indies. Large areas in several parts are there occupied by what has been called the Laterite formation, and from the various aspects it assumes, always however preserving its peculiar red color, its origin and true character have been among Indian geologists a subject of great discussion; probably one name has been given to several different things. In a paper communicated in 1838 to the Madras Journal of Science by Dr. Clark, Staff-Surgeon 1st class, now acting P. M. O. in Canada, a description of the laterite is given, and the conclusion arrived at appears to be that it is, or results from a decomposed syenite or hornblendic gneiss, the peroxydation of the iron of the hornblende giving the brick-red color. The Canadian rock seems to be a syenite in an incipient state of decomposition, but whether the color is due to the decomposition of hornblende or iron pyrites, is a question which would require investigation.

Nipissing, I have nowhere seen it in any large mass either around the lake or on the French River; nor have I heard of the existence of any such mass from the Indian inhabitants of whom I have frequently and repeatedly made enquiry. Indeed the only mass of ore of any kind that I have become aware of, as of economic importance, is the specular oxide of iron on Iron Island, of which an account was given in last year's Report.

I have the honour to be,

Sir,

Your most obedient servant,

ALEXANDER MURRAY,

Assistant Provincial Geologist.

REPORT

FOR THE YEAR 1856,

OF

ALEXANDER MURRAY, Esq., ASSISTANT PROVINCIAL GEOLOGIST,

ADDRESSED TO

SIR WILLIAM E. LOGAN, PROVINCIAL GEOLOGIST.

MONTREAL, 1*st March*, 1857.

SIR,

In pursuance of the directions you were pleased to give me at Toronto, last spring, I have been employed during the past summer and autumn in making further explorations of the region north of Lake Huron.

Commencing at the Hudson's Bay Company's post, on the Sturgeon River of Lake Nipissing, I scaled the Sturgeon River for about fifty-two miles; then leaving the main stream I followed up the course of the Maskanongi, for about thirty miles farther, passing through a succession of lakes to a point at the southern end of one called Matagamashing, where the waters of the Sturgeon River are divided from those of another large south-flowing stream, tributary to the French River, called the Wahnapitae or Wahnapitaeping. Crossing the water-shed, I then explored a large lake known as Wahnapitaeping Lake, and continued the measurement on the stream flowing from it, to its junction with the French River, and thence down the middle outlets of the French River to Lake Huron, in all a distance of about eighty miles. A measurement

was also effected of a northerly channel of the French River, hitherto only frequented by the Indians, which leaving the main body of the stream, at the lake above the Rapide du Pin, rejoins it at the lake above the Grand Recollet Fall.

Another measurement was likewise made from the Wahnapitae River, along an Indian travelled route, by the waters of the White-fish River to White-fish Lake, the latter being the head water of one of the branches of the Spanish River. Finally the chain of lakes which constitute the waters of White-fish River was followed to its junction with Lake Huron, near the Wallace Mine location.

In proceeding from Collingwood to enter upon this work, I should, in consequence of an accident which had happened to the only steamer on the route, have been subject to much delay and inconvenience, but for the timely assistance of Mr. A. P. Salter, P.L.S., whom I am desirous of taking this opportunity to thank for the conveyance of myself and assistant Mr. Brown, together with my supplies for the season, to Shibahahnahning, where a party of Indians were waiting my arrival.

Mr. Salter, at the time I met him, was on his way to Lake Nipissing, from the vicinity of which lake he had instructions from the Crown Land Department to run a true west line, as a basis for future settlements; the measurements on which line made subsequently, and crossed by me at various parts during the season, have rendered me good service as checks upon my own work; and I have still farther to acknowledge Mr. Salter's aid in kindly furnishing me with a copy of a sketch he had previously made of the White-fish branch of the Spanish River.

The whole of the ground measured by myself, together with such portions of Mr. Salter's base and meridian lines as were visited, and his sketch of the White-fish branch of the Spanish River, I have plotted on a scale of one inch to a mile; and I am pleased to have it in my power to state that the various checks employed, by latitude repeatedly calculated, by Mr. Salter's measurement, and finally by the longitudinal position of the mouth of the White-fish River, as represented on Bayfield's charts, all tend to prove the work as tolerably accurate. I now beg to submit the plan which I have drawn of the same, together with this Report, for your approval.

GEOGRAPHICAL DESCRIPTION.

Sturgeon River and Maskanongi Branch.

The Hudson Bay Company's post, on the Sturgeon River, where the survey commenced, is situated in latitude, by observation, 46° 20′ 22″ N., and longitude, by account, 80° 1′ W. Following the course of the stream upwards, its general bearing is north-easterly for about nine and a-half miles, in a straight line, but the distance amounts to twelve miles and seventy chains, following the sinuosities of the stream. This is to the mouth of a tributary falling from the eastward, generally known as Smoke River; near this point the main river makes a sudden bend, and points north-westerly, making a general course in that direction for a straight distance of about twenty-eight miles and a-half, or along the surface of the river and including its bends, a distance of thirty-six miles and a-quarter.

Within this last distance the river is joined by two large tributaries, one called the Tomikamico, about five miles and a-half above the Smoke River, which flows from the north-eastward; the other, the Temagamang branch, about seventeen miles higher up; it flows from Lake Temagamang, a large sheet of water lying to the westward of Lake Temiskamang. At the end of the last distance the stream bends to a general course about north by east, and reaches the junction of the Maskanongi branch a little within three miles.

Following the Maskanongi from the junction, the general course of the stream, which is small and very rapid at the mouth, is about N. W. by N. for two miles and three-quarters; above this it opens into a small lake, the lowest of a long chain of lakes, connected with each other by short rapid streams extending the remainder of the distance; these waters were followed. The lakes, in succeeding each other, make first a general upward course of south-west for five miles, then bending round they bear up northerly, presenting a long sheet of water known by the Indians as Maskanongi-wagaming; and a smaller one beyond, which reaches the latitude 46° 51′ 18″ N., and longitude, by account, 80° 32′ 0″ W. From this point

this valley of lakes again turns southerly, first bearing W. by S. about three miles and reaching Matagamashing Lake, which turns S. S. W. for about six miles, and is joined by a long narrow arm from the N. N. W., at the head of which the stream comes in small and rapid, and does not appear to be farther navigable. The main body of Matagamashing Lake, below the junction of the north-east aud north-west arms, lies nearly due north and south, reaching three miles to the latitude 46° 44′ 13″ N., at its extreme southerly end.

The Sturgeon River is in general easily navigated as far as it was ascended, although the current is strong nearly the whole way; there are three falls and two rapids below the Smoke River which require to be portaged, ascending the stream; but the rapids can be *run* in the descent. Above Smoke River about a mile, is Smoke Fall, a fine chute of twenty-nine feet, above which there is no farther impediment to the navigation than the strength of the current until passing about three miles beyond the Temagamang branch, where a set of rapids occur which are generally portaged. Above this there are three other sets of rapids below the Maskanongi branch, all requiring to be portaged on the ascent, but capable of being run under ordinary circumstances in the descent.

At the outlet, the Maskanongi is very rapid, and the streams connecting the lakes are so likewise; and they are frequently broken by falls, where portaging is required. The whole ascent on its waters, together with the rise on the Sturgeon River amounts to 285·20 feet above the ordinary level of Lake Nipissing, or 932·20 feet above the sea, as will be seen by the following tabular arrangement.

Levels of the Sturgeon River and its tributary, the Maskanongi, above the Sea.

	Distance. Miles.	*Rise.* Feet.	*Total Dist.* Miles.	*Height above the Sea.* Feet.
Level of the Sturgeon River at its junction with Lake Nipissing above the sea.....				647 Lake Nipissing.
Rise in the river, from its mouth along the course of the stream to H.B.C.s post, estimated at 0·50 ft. p. mile	1·60	0·80		

	Distance. Miles.	Rise. Feet.	Total Dist. Miles.	Height above the Sea. Feet.
Rise in current from H. B. C's post, to foot of a fall near Salter's base line, 0·50 ft. per mile................	2·90	1·45		
—— from smooth water below to smooth water above the fall	0·04	5·20		
—— in current across the pool above the fall...........	0·10	0·06		
—— in fall from smooth water at the foot to smooth water at the head............	0·12	26·00		
—— in current above the fall, which is pretty strong, and was estimated at the rate of 0·80 ft. per mile.......	5·96	4·77		
—— in fall from smooth water below to smooth water above..................	0·06	16·50		
—— in current (strong) 0·80 ft. per mile................	2·10	1·68		
—— in two rapids, including the current between, from smooth water below to smooth water above	0·50	6·10		
—— in current up to the mouth of the Smoke River, estimated at 0·80 ft. per mile	1·10	0·88	14·48	710·44 Smoke River.
—— in current up to smooth water below Smoke Fall, estimated at 0·80 foot per mile..................	0·75	0·60		
—— in Smoke Fall, from smooth water below to smooth water above the fall.....................	0·26	29·30		
—— in current above the fall estimated at the rate of 0·80 foot per mile........	0·50	0·40		
—— in rapid from smooth water below to smooth water above.................	0·10	0·80		
—— in current to the mouth of the Tomikamico, at 0·80 foot per mile...........	4·82	3·86	20·91	745·40 Tomikamico.

	Distance. Miles.	Rise. Feet.	Total Dist. Miles.	Height above the Sea. Feet.	
Rise in current, to the junction of the Temagamang branch, the water rapid, estimated at 1·00 foot per mile......	17·06	17·06	37·97	762·46	Temagamang.
—— in current above the Temagamang (very fast) estimated at 1·00 foot per mile	3·25	3·25			
—— in rapid from smooth water below to smooth water above..................	0·12	3·62			
—— in current (very fast) estimated at 1·00 foot per mile	3·72	3·72			
—— in rapid, from smooth water below to smooth water above..................	0·18	4·58			
—— in current estimated at 1·00 foot per mile........	0·80	0·80			
—— in rapid from smooth water below to smooth water above..................	0·24	6·16			
—— in current (very fast) estimated at 1·00 foot per mile	0·36	0·36			
—— in rapid from smooth water below to smooth water above..................	0·12	4·35			
—— in current (very fast) estimated at 1.00 foot per mile	1·22	1·22			
—— in rapid, from smooth water below to smooth water above, ...	0·30	7·91			
—— in current, estimated at 1·00 foot per mile,.......	2·60	2·60			
—— in rapid, from smooth water below to smooth water above,............	0·34	5·87			
—— in current, to junction of the Maskanongi River, very fast,...............	1·26	2·25	52·48	809·15	Maskanongi.
—— in a succession of rapids, from smooth water below to smooth water above, on the Maskanongi,.........	0·24	15·56			
—— in current, estimated at 0·80 foot per mile.......	1·27	1·02			

	Distance. Miles.	*Rise.* Feet.	*Total Dist.* Miles.	*Height above the Sea.* Feet.	
Rise in rapid, from smooth water below to smooth water above,............	0·03	0·80			
—— in current, estimated at 0·80 foot per mile,.......	1·45	1·16			
—— in fall and rapids, from smooth water below to smooth water above,.....	0·06	10·31			
—— in current, estimated at 1·50 ft. per mile, very fast,	0·10	0·15			
—— in first lake, estimated at 0·20 foot per mile,.......	0·50	0·10	56·13	838·25	First lake.
—— in rapid between first & second small lakes	0·10	1·00			
—— in sec'd lake to connecting stream, 0·20 foot per mile,	0·77	0·15	57·00	839·40	Second lake.
—— in current in narrows, joining second and third lakes,	0·10	0·10			
—— in third lake, to junction of stream above 0·20 foot per mile................	2·60	0·52	59·70	840·02	Third lake.
—— in a succession of falls and rapids on connecting stream, from smooth water below to sm'th water above	0·10	11·07			
—— in fourth lake, estimated at 0·10 foot per mile,.....	5·85	0·59	65·65	851·68	Fourth lake.
—— in current and fall on connecting stream, between fourth lake and Maskanongi Lake,............	0·05	10·63			
—— in Maskanongi-wagaming Lake, from foot to head, estimated at 0·10 foot per mile, ...	6·70	0·67	72·40	862·98	Maskanongi-wagaming.
—— in current in stream above lake, estimated at 0·50 ft. per mile, ...	0·34	0·17			
—— in rapid, from smooth water below to smooth water above, ...	0·10	10·06			
—— in current from rapid to opening of small lake, esmated at 0·50 ft. per mile,	0·10	0·05			
—— in sixth lake, estimated at 0·10 foot per mile,.......	0·45	0·05	73·39	873·31	Sixth lake.

	Distance. Miles.	Rise. Feet.	Total Dist. Miles.	Height above the Sea. Feet.	
Rise in rapid between small lakes on connect'g stream	0·08	1·80			
—— in seventh lake, to junction of connecting stream,	1·75	0·16	75·22	875·27	Seventh lake.
—— in rapid, on connect'g str'm between small lakes,.....	0·16	27·02			
—— in eighth lake, to junction of connecting stream, 0·10 foot per mile, ...	0·38	0·04	75·76	902·33	Eighth lake.
—— in rapid, on connecting stream, from smooth water below to smooth water above, ...	0·20	5·00			
—— in ninth lake, to stream at foot of rapids, 0·10 foot per mile, ...	0·50	0·05	76·46	907·38	Ninth lake.
—— in fall and rapids, from smooth water below to smooth water above, on connecting stream, ...	0·15	19.30			
—— in current, on stream above fall, which is very fast for most part of the way, to the foot of a fall, estimated at 2·00 feet per mile, ...	0·16	0·32			
—— in fall, from smooth water below to smooth water above, to the level of the lower end of Matagamashing Lake, ...	0·02	4·50			
—— in Matagamashing Lake, to the centre part of the lake, where the north-west and north east arms of the lake unite, estimated at 0·10 foot per mile, ...	7·00	0·70	83·79	932·20	Matagamashing

In the valley of the Sturgeon River, below the Temagamang branch, there are many parts susceptible of improvements, especially on the flats near the river, which are occasionally wide and extensive.

At the mouth of the river, below the Hudson's Bay post, there is a wide tract of *prairie*, yielding a rank growth of wild

grass, interspersed here and there with clumps of low trees and bushes, where the cattle belonging to the Company, which have become numerous, range at pleasure, and amply testify by their admirable condition to the capabilities of the soil from which they derive their subsistance. Partially surrounding this prairie tract, along the margin of the lake, there is an extensive marsh, already become somewhat celebrated for the quantity and quality of the cranberries it annually supplies.

On the east side of the river, opposite the Hudson's Bay Company's post, and on both sides above, until nearly reaching the basin below the lowest fall, the soil appears to be of good quality, giving a mixture of hard-wood and evergreens, among the latter of which there is some good white pine. Small portions of this land have already been partially cultivated by the Indians and servants of the Hudson's Bay Company, and the crops resulting from such cultivation, particularly in potatoes, have generally proved very productive. There are many spots also, of equally good quality, above the falls, although portions are rocky and barren ; but after making the ascent to the Smoke Fall, the meanders of the river pass through a tolerably level country, where the banks exhibit sections of drab-coloured clay, overlaid with sand, most of the way, as far up as the Temagamang. The soil on these flats is chiefly a sandy loam, bearing in many instances large-sized yellow birch, elm, maple and white pine.

Above the Temagamang, the country becomes more broken than it is below, and the flats are less extensive, and before reaching the Maskanongi it becomes for the greater part poor and rocky. White and red pine, tamarack, and a species of fir, which I was informed by Mr. Salter is recognised as the American cypress, constitute the greater part of the indigenous growth. The first three are frequently large and probably good timber, but the last, which never attains a very large size, is usually stunted in appearance, and invariably indicates a very barren soil.

Rising the valley of the Maskanongi, the country assumes a mountainous character, with abrupt and precipitous hills

on either hand, varying in elevation from 200 to 300 feet, until reaching Maskanongi-wagaming, where the highest elevation, according to my measurement, was 489 feet. Farther up the valley, to the north of Matagamashing, near the sources of the Maskanongi, the hills are still more lofty, and are nearly destitute of timber, rising apparently to the height of from 600 to 700 feet above the level of Matagamashing.

There are but very few spots on the Maskanongi that can be fairly represented as possessing capabilities worthy of much attention for the purposes of agriculture. Portions of the lower part of the valley produce abundance of good sized pine, especially of the red variety; but the upper part, particularly the country surrounding the two largest lakes—Maskanongi-wagaming and Matagamashing—is almost entirely a continuous succession of barren ridges of rock, where the greatest proportion of the few and scattered forest trees consist of dwarfish red pine and cypress.

North Channel of the French River.

The western outlets from Lake Nipissing, of which mention was made in last year's Report, meet in their downward course, and fall in a fine cascade into the northern bay of the lake, or expansion above the Rapide du Pin. From the centre part of this expansion, about one mile south from the fall, the course down the north channel is very nearly due west, for about nineteen miles; and, excepting about two and a-half miles at the lower end of that course, where it turns a little more northerly, the whole of that distance is very nearly a straight line. The course then turns due south, the channel opening out into a succession of lakes, and at the end of about six miles, joins the middle or old-travelled channel, about two and a-half miles above the Grand Recollet Fall.

The navigation of the northern channel is interrupted by four rapids and one fall, but portaging becomes necessary only at two places, the one being at the most violent part of the uppermost rapid, about seven and a-half miles below the lake which is above the Rapide du Pin; the other at the fall which joins the lower two lakes.

The estimated fall in these rapid parts of the channel is as follows:—

	Feet.
The upper rapids, called on the map the Three Rapids, ...	6·00
The 2d rapid, about three-quarters of a mile below the upper rapids, ...	1·00
The 3d rapid, a little below the part where the channel takes the northward bend on its western course, two and three-quarter miles from the south bearing lakes, ...	1·00
The 4th rapid, half-a-mile below the 3d, ...	2·50
The fall which empties the lake above the Grand Recollet Fall, ...	10·00
	20·50

An island divides the channel at the junction with the lower lakes, at the north-west end of which the waters fall perpendicularly nearly the whole ten feet, while at the south-east end, the same descent is made in long and violent rapids.

Immediately north from the part where the channel leaves the lake above the Rapide du Pin, a narrow arm or bay joins, extending W. N. W. about three and a-half miles, with an average breadth of about a-quarter of a mile, at the head of which a stream falls in. The stream is small and narrow at the entrance, but opens out in still or slow flowing water a few chains up, and is navigable for from four to five miles, keeping a straight course about N.W.

In its general characteristics, the north channel differs in no way materially from other parts of the French River, as described in former Reports. The country along its banks is for the most part rocky and barren, the shores bold and precipitous, but nowhere rising to such an elevation as to be termed mountainous. At the head of some of the bays, and on the lakes at the northern end, there are occasional patches of good land, where the surface is tolerably level, and hardwood timber, mixed with large-sized pine, is the principal growth; but these do not appear to be of any great extent anywhere in the immediate vicinity of the river.

Wahnapitae River and Middle Outlet of French River.

Two outlets of the French River join Lake Huron within about two miles of each other, directly north of the cluster called the Bustard Islands, the western one being about five

miles east from the entrance to the channel usually travelled, of which a description was given in my Report for 1847. Following the more western of the two channels, the course up is about N.N.E. for a little more than two miles, when the stream becomes rapid, and turns abruptly to a bearing north of east. At about a mile and three-quarters from the turn the two channels unite, the eastern one bearing down towards Lake Huron, exactly parallel with the lower part of the western.

From the junction, while the upward bearing of the eastward outlet is in the same line, but in an opposite direction to the downward, the channel that connects the western and eastern outlets crosses the latter and continues straight to a parallel depression, over a mile distant. This third depression presents a long narrow sheet of water, turning southward towards Lake Huron, but terminating in a bay without reaching it, while its upward course, like that of the depression of the eastern outlet, carries us to the main travelled channel of the river in about three miles.

The eastern of the two outlets joins Lake Huron over a strong rapid, where the water is pent up for a considerable distance, within a narrow gorge of bold precipitous cliffs; but immediately above the rapid, it opens out into a small round-shaped lake, and continues to present perfectly smooth water, with a scarcely perceptible current up to the junction of the main river, expanding as it approaches the main channel, and widening on the other side of it into a small lake, which with a few degrees more of easting in its bearing, has a length of about two miles and a-half, with an average breadth of three-quarters of a mile.

At the north-east angle of the lake, a large channel comes in, which is said to connect with the main river, about half way between the lower part of the lake and the Grand Recollet Fall; and at the north-west angle another channel comes in from the westward, which is one of the mouths of the Wahnapitae River.

Ascending this outlet of the Wahnapitæ for a mile west and then a mile north-west, we reach the point where the river splits into two; the other branch running south-west for about

four miles joins the main travelled channel of the French River just where another channel appears to separate from it, taking a westward direction; but where this is discharged into Lake Huron, and whether there are any other outlets to the westward for this very complicated distribution of waters, as I was informed by some of the Indians that were with me, would require some farther investigation.

From the point where the Wahnapitae separates into two channels, a true meridian line, or a bearing about N. 4° E. by compass, will in twenty-two miles and a-half strike Mr. Salter's base line, where it crosses the river; and thence a course N. 4° W., for six and a-quarter miles farther, will reach the route where we struck off from the Wahnapitae for the White-fish River. But although the general bearing is thus far nearly due north, the river makes several extensive sweeps on either side of that line within the distance, and measures along its surface thirty-one miles and fifty-eight chains to Salter's base line, and thirty-eight miles and twenty-two chains to the White-fish River route. From the White-fish River route two more general courses on the Wahnapitae, the first north-east twelve miles, and the second north nine miles, reach the large lake called Wahnapitaeping, and although there are several minor turns within these two courses, the whole measured distance along the surface, from the same starting place, is only about two miles in excess, being twenty-three miles, or sixty-four miles and fifty-six chains from the mouth.

From the outlet at Wahnapitaeping, a line eight and a-half miles in a north-west bearing crosses the lake and strikes the continuation of the main river, the upward course of which is about N.N.E. for a little over a mile; but beyond that distance it bends more north-easterly, and becomes very tortuous. After bearing north-easterly about two miles in a general course, the valley turns gradually round towards the north-west, and continues in a north-westerly bearing as far as the stream was followed.

The navigation of the Wahnapitae up to Wahnapitaeping Lake is attended with considerable difficulty, being frequently interrupted by falls and long violent rapids, the current of the whole stream at the same time being very strong, especially

above the White-fish River route. A current becomes perceptible upon entering the eastern mouth of the stream, immediately after leaving the French River bay, and at one place, a little over half-a-mile up the channel, there is a rapid, giving a fall of about a foot and a-half. Above the bifurcation of the river, there are fourteen falls, and one *jam* of drift-wood, where portages are necessary, both ascending and descending, and there are several rapids besides, which require to be portaged when ascending the river, although they can mostly be run when proceeding downward.

The tributaries of the Wahnapitae are all small, two only being navigable for any considerable distance, and consequently there is but a small appreciable difference in the volume of the water from the junction with the French River to Lake Wahnapitaeping. One of the two tributaries flows from the north-westward, and joins the main river on its right side, about half-way between the mouth and Salter's base line; the other flows from the south-east, and joins on the left side, about two miles above the base line.

Levels of the Wahnapitae River above the Sea.

	Distance. Miles.	*Rise.* Feet.	*Total Dist.* Miles.	*Ht. above the Sea.* Feet.	
Level of Lake Huron, ...				578·00	Lake Huron.
Rise on the French River to the junction at the bay below the mouth of the Wahnapitae, ...		8·80			
—— in the smooth water of the bay, estimated at 0·20 foot per mile,	2·60	0·52	2·60	587·32	Mouth of Wanapitae.
—— in the western outlet of the river, up to smooth water below the lowest rapid, estimated at the rate of 0·80 foot per mile, ...	1·50	1·20			
—— in rapid on the outlet half way up, ...	0·06	1·50			
—— in current, to the bifurcation of the river, estimated at 0·50 foot per mile, ...	0·74	0·37	4·90	590·39	Bifurcation.
—— to still water below a fall, estimated at 0·80 foot per mile, a fast current, ...	1·45	1·16			

	Distance. Miles.	Rise. Feet.	Total Dist. Miles.	Ht. above the Sea. Feet.	
Rise in fall, from smooth water below to smooth water above,.	0·06	10·00			
—— in fast current to foot of fall, estimated at 1·00 foot per mile,	1·16	1·16			
—— in fall, from smooth water below to smooth water above,...	0·02	10·00			
—— in fast current, estimated at 1·00 foot per mile, ...	1·48	1·48			
—— in rapid below a whirlpool, from smooth water below to smooth water above,.........	0·02	0·60			
—— in current along stream, below whirlpool, ...	0·14	0·18			
—— from smooth water below whirlpool to smooth water above a rapid,...............	0·10	3·50			
—— in current, estimated at 1·00 foot per mile, ...	0·65	0·65			
—— in rapid, ...	0·20	3·00			
—— in strong current, the whole distance estimated at the rate of 1·00 foot per mile,.........	4·56	4·56			
—— in fall, ...	0·08	7·00			
—— in current, estimated at 1·00 foot per mile, ...	1·27	1·27			
—— in rapid, ...	0·06	0·80			
—— in current, estimated at 1·00 foot per mile, ...	2·96	2·96			
—— in fall, ...	0·10	7·00			
—— in fast current, to the junction of a branch falling in on west side, estimated at 1·00 foot per mile, ...	4·64	4·64	23·85	650·35	Tributary.
—— in current to Beaver Marsh Brook, estimated at 1·00 foot per mile, ...	4·54	4·54	28·39	654·89	Beaver Marsh Brook.
—— in falls and rapids, including the current below each, from smooth water below to smooth water above, viz.:— Rapid, ...3·50; Falls and rapids, ...8·00; Falls and rapids, ...6 00	0·50	17·50			
—— in current, estimated at 1·00 foot per mile, ...	0·20	0·20			

	Distance. Miles.	Rise. Feet.	Total Dist. Miles.	Ht. above the Sea. Feet.	
Rise in rapid,	0·02	0·50			
—— in current, estimated at 1·00 foot per mile,	1·11	1·11			
—— in rapid,	0·06	1·50			
—— in current estimated at 1·00 ft. per mile,	0·40	0·40			
—— in fall, including rapid below,	0·10	35·00			
—— in current between falls, estimated at 1·00 foot per mile,...	0·55	0·55			
—— in falls and rapids,	0.06	37·00			
—— in current, estimated at 1·00 foot per mile,	1·74	1·74			
—— in rapid,	0.02	0·50			
—— in current, estimated at 1·00 foot per mile,	2·17	2·17			
—— in fall,	0·04	7·00			
—— in current, up to the crossing of Salter's base line, estimated at 1·00 foot per mile.	1·27	1·27	36·63	761·33	Salter's base line.
—— in current, estimated at 1·00 foot per mile,	0·50	0·50			
—— in fall, at lat. 46° 22′ 8″,....	0·01	7·50			
—— in current above the fall up to tributary at camp of 20th September, estimated at 1·00 foot per mile,	1·50	1·50	38·64	770·83	Tributary.
—— in current, estimated at 1·00 foot per mile,	2·24	2·24			
—— in rapid,	0·04	1·50			
—— in current, estimated at 1·00 foot per mile, up to the creek, on the route to White-fish River,	3·26	3·26	44·18	777·83	Route to White-fish River.
—— in current, very fast, estimated at 1·50 ft per mile,	1·70	2·55			
—— in rapid,	0·10	5·00			
—— in current, very fast, estimated at 1·50 ft per mile,	0·60	0·90			
—— in falls and rapids,	0·26	60·00			
—— in current, estimated at 1·50 ft per mile,	5·50	8·25			
—— in rapid,	0·08	2·00			
—— in current, estimated at 1·50 ft per mile,	0·34	0·51			
—— in fall,	0·02	10·00			

	Distance. Miles.	Rise. Feet.	Total Dist. Miles.	Ht. above the Sea. Feet.	
Rise in current, estimated at 1·50 ft per mile,....................	0·58	0·87			
—— in strong rapid, ...	0·16	6·00			
—— in current to foot of fall, estimated at 1·50 ft per mile,.....	0·87	1·30			
—— in fall, ...	0·01	7·00			
—— in current across pool between falls, estimated at 1·50 ft. per mile,......................	0·21	0·32			
—— in fall, ...	0·01	8·00			
—— in current, estimated at 1·50 ft per mile,.................	2·60	3·90			
—— in fall, ...	0·01	6·00			
—— in current, very strong, estimated at 2·00 feet per mile,...	0·31	0·62			
—— in rapid, ...	0·05	2·00			
—— in very strong current, estimated at 2·00 feet per mile, ..	5·00	10·00			
—— in rapid, ...	0·12	7·00			
—— in current, very strong, estimated at 2·00 feet per mile,...	1·30	2·60			
—— in rapid, ...	0·28	8·00			
—— in current above rapid, where the river is wider, estimaied at 0·80 foot per mile,.........	2·75	2·20			
—— in rapid to outlet of Wahnapitaeping,.................	0·14	5·00	67·18	937·85	Wahnapitaeping.

Between Lake Huron and the head of the bay north of the main channel, the country is bold, rocky and barren, like most other parts of the French River; but on the eastern outlet of the Wahnapitae, towards the bifurcation, there is some tolerably good flat land, bearing hard-wood mixed with evergreens. The valley of the Wahnapitae south of the White-fish River route contains many considerable tracts of flat land, much of which appears to be of good quality, bearing hard-wood and large white pine in abundance; but a great proportion of the flats are low, wet and swampy; and this is particularly the case where the river makes a long westerly sweep about halfway between the mouth and Salter's base line.

There are likewise portions of the valley above the White-fish River route where the land is of tolerably good quality, but the flats at that part of the river are less extensive, and the general character becomes much more rugged and broken than it is farther down.

Wahnapitaeping Lake is a fine sheet of water, surrounded by picturesque hills and studded with numerous islands. On the north side it assumes a semi-elliptical form, the regularity of which is broken by a projecting delta running out into low flats at the junction of the river. On the south side a bold rounded promontory separates two long narrow bays lying directly north and south, the river flowing out of the southern extremity of the eastern one. The shores on the east and west sides are less symmetrical than on the north and south, being indented by numerous coves and long narrow bays. The greatest breadth of the lake from north to south is a little less than nine miles, and the extreme breadth from east to west is rather over ten miles, including a deep bay on each side. The whole area of the surface contains from forty to fifty square miles.

The river above the lake after leaving the flats at the mouth, meanders through a great sandy plain, clad almost exclusively with red pine. It sweeps round the base of a great mountain which rises to the westward of it, till the upward course gets round to the north-west, when it enters the gorge of a narrow valley, with rocky lofty precipices on either side.

With the exception of there being a pretty strong current to stem, and a jam of drift wood, blocking up the river about a mile and a-half above the lake, there are no impediments to its navigation for from ten to twelve miles, but at about that distance it again becomes broken by rapids.

White-fish River and its Lakes.

Leaving the Wahnapitae at the place already indicated as the White-fish River route, a small rivulet is ascended for a few chains, and then a portage made due west thirteen chains, to a small narrow lake about a mile in length, lying north and

south, which supplies the little rivulet. From a bay on the west side of this small lake another portage is made west, fifteen chains to a second small lake, and then crossing that lake in a course about W. S. W. thirty chains, a third portage is reached which crosses the water-shed, dividing the waters of the Wahnapitae from those of the White-fish River. The course across the portage is S. W. by W. twenty-two chains, striking at its western termination the extreme head of a small narrow lake, the summit water of the main branch of the White-fish River.

The White-fish River in its whole length, until within a mile or less of Lake Huron, consists of a long chain of lakes, lying at short distances from one another, connected by short, small and sometimes rapid streams.

From the head lake a straight line in the bearing W. S. W. for a little over seventeen miles, reaches a circular-shaped lake named Round Lake, but sometimes spoken of as White-fish Lake, thus giving rise to much confusion, as the lake generally recognised by the latter name belongs to another stream, and gives its tribute to the Spanish River.

Continuing across Round Lake in nearly the same bearing as before, two miles bring us to the outlet. The stream, as it flows from the lake, takes a general course of about S. W., and in about two miles enters Lake Lavase, which, with the small stream issuing from it, gives us two miles more in the same direction to the head of Lake Panache. This is the largest lake of the series; its length, following the travelled route, is about eleven miles, in a bearing W. by S., and then two miles in a bearing south. At its lower extremity there is a narrow gorge with a fall into another lake. From the fall the downward course of the valley, over lakes and streams, is south for about two miles, and then west for about eight miles.

Below this the general bearing to the mouth is south-west, and the distance about four miles, in which are crossed three small parallel east and west lakes, the lowest two being about three-quarters of a mile above the position where the river joins Lake Huron, less than a mile eastward of the Wallace mine location, in latitude 46° 6′ 26″ N., and longitude, by account, 81° 45′ 48″ W.

The following tabular arrangement gives the levels of White-fish River over the sea:

Levels of White-fish River above the Sea.

	Distance. Miles.	*Total Rise.* Feet.	*Total Dist.* Miles.	*Ht. above the Sea.* Feet.	
Level of Lake Huron, ...				578·00	Lake Huron.
Rise in the stream above the junction, estimated at the rate of 0·80 foot per mile, to the foot of the lowest fall, ...	0·80	0·64			
—— in fall, ...	0·03	37·00			
—— across pool, between falls, estimated at 0·50 foot per mile,...	0·11	0·06			
—— in falls, ...	0·05	14·00			
—— across lower lake, estimated at 0·10 foot per mile, ...	1·00	0·10	1·99	629·80	First lake.
—— in stream between lakes, estimated at 0·50 foot per mile,..	0.38	0·19			
—— in lake to foot of rapids, estimated at 0·10 foot per mile,...	1·70	0·17	4·07	630·16	Second lake.
—— in a succession of falls and Rapids, forming the connecting stream between lakes, ...	0·60	100·00			
—— across lake to the junction of stream below fall, estimated at 0·10 foot per mile, ...	0·30	0·03	4·97	730·19	Third lake.
—— in fall, ...	0·05	11·00			
—— in stream to foot of fall, estimated at 0·80 foot per mile,...	0·44	0·35			
—— in fall, ...	0·01	7·00			
—— in a long lake above the fall, estimated at 0·20 foot per mile,	5·75	1·15	11·22	749·69	Fourth lake.
—— in rapid, at lat. 46° 10′ 22″,...	0·02	1·00			
—— in stream, estimated at 1·00 ft. per mile, ...	0·90	0·90			
—— in rapid, ...	0·01	2·50			
—— in lake above rapid, estimated at 0·20 foot per mile, ...	1·26	0·25	13·41	754·34	Fifth lake.
—— in rapid, ...	0·05	3·50			
—— in lake above rapid, estimated at 0·20 foot per mile, ...	1·65	0·33	15·11	758·17	Sixth lake.
—— in same lake, a narrower part, estimated at 0·25 foot per mile,	1·25	0·31			
—— across lake to foot of falls below Lake Panache, estimated at 0·20 foot per mile, ...	1·00	0·20	17·36	758·68	Lake Panache

	Distance. Miles.	Total Rise. Feet.	Total Dist. Miles.	Ht. above the Sea. Feet.	
Rise in fall from Lake Panache, ...	0·02	8·00			
—— along surface of Lake Panache, estimated at 0·10 foot per mile,	13·00	1·30	30·38	767·98	Eighth lake.
—— on connecting stream above Lake Lavase, estimated at 0·50 foot per mile, ...	0·56	0·28			
—— on Lake Lavase up to the lower point of the marsh, estimated at 0·20 foot per mile, ..	1·00	0·20	31·94	768·46	Lake Lavase.
—— in current, moderately strong, up through the marsh, and up the stream to the foot of the rapids below Round Lake, estimated to average 0·80 foot per mile nearly, ...	2·60	2·08			
—— in two rapids, including current between, up to the level of Round Lake,...............	0·11	5·00	34·65	775·54	Round Lake.

A small brook falling into Round Lake, on the north side, issues from another lake called Muckataewagaming, lying parallel to the upper chain; to this lake there is a portage of about half-a-mile, long used by the people connected with the Hudson's Bay Company, when on their way to the post of White-fish Lake. From the north end of this portage a bearing of N. N. E., and a distance of a little over a mile across Lake Muckataewagaming strikes the southern termination of Salter's meridian line, and also the end of a portage, both of which cross the water-shed and come upon White-fish Lake at a distance of from twelve to fourteen chains.

The lakes above Round Lake, of which there are five, are all long and narrow; the lowest one of the series measures upwards of ten miles in length from head to foot, but is nowhere thirty chains wide, except at the lower end, where the breadth is about three-quarters of a mile. Muckataewagaming lies exactly parallel with this long lake, and measures from four to five miles in length, with a breadth never exceeding half-a-mile. Round Lake, as its name implies, is nearly circular, with a diameter averaging about a mile and three-quarters; in addition to the tribute received by Round

Lake from the head lakes to the east, and from Muckataewagaming, to the north, a third tributary enters it on the west side, about three-quarters of a mile above the outlet.

The country surrounding these upper lakes is for the most part very broken and rocky, few parts claiming much consideration for their agricultural capabilities; but pine grows abundantly of both the red and white varieties, and the white pine is frequently of large size. On the north side of Round Lake, between it and Muckataewagaming, there is a considerable extent of land yielding stout maple and oak, mixed with large-sized white pine, where the soil is evidently of good quality, but the surface is for the most part rugged and stony.

The same description will equally apply to the country on the north-west side of the water-shed, bordering on White-fish Lake, where patches have been partially cultivated around the Hudson's Bay post, producing potatoes of the finest description, but the places capable of yielding them, or of being cultivated at all are confined to very narrow limits, from the irregularity and general rocky character of the ground.

The banks of the stream falling from Round Lake are generally flat and dry about the upper end, bearing balsam, small white birch, cedar and tamarack; but they become gradually lower and more swampy towards Lake Lavase, and the stream after passing through a low and wet tract, producing black ash, and black oak of stunted size, opens out at the junction with the latter into an extensive marsh.

The upper half of Lake Lavase is all marsh, averaging about half-a-mile in width, and bounded on each side by bold rocky hills; the lower half is alternately rocky and marshy at the points and in the bays, and the banks of the connecting stream flowing from it are low and marshy to the junction of Lake Panache.

About two miles below the junction, Lake Panache opens out over a great area, extending several miles to the southward in a great south bay, which constitutes the main body of the lake. From this bay an arm extends in a general bearing about E. S. E. for six miles, reaching longitude, by account,

81° 12′ 55″ W., and giving a total length to the lake from its eastern to its western extremity of about eighteen miles; from the western end of the lake, another arm extends northerly, but that part was not examined, and I am consequently unable to describe its limits.

The north shore of Lake Panache, from the junction of the stream from Lake Lavase to the western extremity, where the northern arm branches off, is tolerably regular, and it is bold and rocky most of the way; but the coast on the south side and up the eastern arm is deeply indented by bays of great extent; numerous islands, many of which, especially those about the centre, are of large size, are distributed over the surface of the lake. The surrounding country is for the most part rugged and rocky, and the soil is no where in the vicinity of the lake of a higher character than to enable it to support a moderately good growth of red pine.

The lakes below Lake Panache, which all lie transversely to the course of the fast-flowing parts of the streams that unite them, are narrow, sometimes not exceeding a few chains in width; they are bounded by bold, rugged, barren shores, destitute of attraction as regards the picturesque until reaching the lowest lakes of the series; these wash the base of the range of hills which stretch along the coast of Lake Huron from Lacloche, and though the country is barren, the scenery becomes very beautiful. The hills do not rise to a great elevation; one of the highest was found to be only 369 feet over the level of the small lake at its northern base, or 421 feet above the level of Lake Huron; but the bare white precipitous sides and sharp rugged outline of these hills stamp them with a character which strongly contrasts with that of the surrounding country.

The range here is divided into two ridges of equal elevation by a narrow valley lying east and west, occupied by an arm of the lowest White-fish River lake, on the west, and by a small lake whose waters flow away from the White-fish River on the east. The southern boundary of the range is marked in the valley of the White-fish River, by the last two falls in the stream below. The banks of the stream below the lowest

fall are for the greater part flat, and there is a tract of tolerably good land on either side, yielding principally hard-wood mixed with pine.

DISTRIBUTION OF THE ROCK FORMATIONS.

The rocks of the region explored during the season, embrace two of the oldest recognised geological formatios, the Laurentian and Huronian; the rocks of the latter and more recent of which have been observed to pass unconformably below the lowest of the fossiliferous strata of the Silurian system. The contorted gneiss of the Laurentian series, with its associated micaceous and hornblendic schists, spreads over the country to the south and east, while the slates, conglomerates, limestone, quartzite and greenstone of the Huronian, occupy the north and western parts.

It was stated in my Report on the north shore of Lake Huron, that the eastern limit of the Huronian rocks was to be found in the bay on the north-west side of Shibahahnahning. If a line be drawn from that point to the junction of the Maskanongi and the Sturgeon Rivers, it would run in a north-easterly bearing nearly, and it would rudely represent the common boundary of the two formations; were the junction however followed out in detail between the two points, there would be many deviations from the line, presenting sweeps aud curves in it, sometimes on one side and sometimes on the other, resulting from the effects of undulations.

The difference in lithological character between the two formations was always sufficiently apparent, but though both were frequently found at short distances apart, the immediate point of contact was always obscure; and a mass of greenstone of rather coarse grain was usually the first intimation of the proximity of the higher rocks.

The change was first observed at the junction of the Maskanongi and Sturgeon Rivers, and it was afterwards discovered on the Wahnapitae at two places, one about half-way between the White-fish River route and Wahnapitaeping, and the other crossing the Wahnapitae about four miles above the White-

fish River route; it was again manifested on the first little lake on the White-fish River route after leaving the Wahnapitae, its strike thence being in a course generally parallel to the upper chain of the White-fish River lakes; crossing Salter's base line somewhere near his fifty-second or fifty-third mile, and passing to the eastward of Lake Panache, it runs out at Lake Huron, north of Shibahahnahning, as has been said.

Laurentian Series.

On the Sturgeon River, gneiss of red and grey colours, interstratified with layers of mica slate and quartzite, is displayed at each of the falls and rapids below the Smoke Fall; and the banks occasionally exhibit strata of the same lithological character, always more or less contorted, but having a general dip south or south-east.

At Smoke Fall, the strata, which are otherwise similar to those seen below, are tolerably regular, and shew a dip S. by W., but immediately above the falls they become nearly flat, the angle of inclination not exceeding six degrees in a due south direction. In the long north-western stretch of the valley above Smoke Fall, and below the Temagamang, occasional exposures on the banks of the river exhibit gneiss and quartzite, invariably dipping south; and above the Temagamang, where the rocks are more frequently exposed, there is no remarkable change in the lithological character for several miles, while the general dip continues to be southerly.

Between the lowest two rapids, above the Temagamang, the gneiss is green in parts, deriving its colour from the presence of chlorite, and these chloritic beds are succeeded by and interstratified with beds of red and grey colours; towards the end of the north west stretch, the prevailing color of the gneiss is green, and portions are of a concretionary character, the concretions being enclosed in thin films of chlorite; the general dip is about S. by E.

At the elbow of the river, where it turns northerly, and where a small stream comes in, thinnish beds of fine-grained red and grey gneiss occur; the beds are parted by layers of

yellow mica, and shew a dip south, while similar beds at a short distance up the creek, and just below the part where it first becomes rapid, dip about east. Farther up the river, and at a little distance below the junction of the Maskanongi, the east bank exposes contorted gneiss, with many beds of greenish coloured quartzite. At the junction of the Maskanongi, the rock is rather coarse-grained greenstone, rising on the north side of the tributary in a precipitous hill about 250 feet high.

The rocky banks and bold rounded bluffs of the French River are all gneiss, generally of a red colour, or red and grey, with interstratified portions of micaceous and hornblendic slate. These rocks every where display contortions and are intersected by numerous quartzo-feldspathic and quartz veins, and small fissures and cracks in the rocks are sometimes filled with crystals of black hornblende.

On the north channel of the French River the attitude of the gneiss, independent of small contortions, is sometimes nearly horizontal, but the prevailing dip is from south to south-east.

At the eastern of the two middle outlets, falling into Lake Huron, the gneiss is alternately red and grey; the red is fine grained and compact, the grey coarsely crystalline; the bedding, which is very distinct and tolerably regular, dips E. S. E. $<45^{\circ}$. At this point the gneiss is cut by two sets of granitic veins, one set composed of large coarse crystals of red feldspar, with quartz and mica, running north and south; while the other set, which is fine-grained, and in which the prevalent mineral is red and pinkish feldspar, intersects both the gneiss and the coarser veins. This set runs N. W. and S. E.

On the upper part of the middle channel both north and south of the main river, black hornblendic slates with garnets, are occasionally seen interstratified with the gneiss; but at the northern end of the lake, and on each side of the eastern outlet of the Wahnapitae, the gneiss, which is very much contorted, is chiefly red and grey.

At the falls and rapids of the Wahnapitae, and wherever the rocks are seen in the valley below the White-fish River route,

they were found to consist of red and grey gneiss, generally more or less contorted, but shewing an average dip from south to south-east; and in the country east of the river on Salter's base line the gneiss forms a series of precipitous ridges running N. E. and S. W., all shewing a dip S. E.< about 45°.

On the base line west of the river, the ridges which are there also very precipitous, at some parts run nearly north and south, and the strata sometimes appear to be vertical, but always more or less contorted.

At the sixty-feet fall and rapids, about two miles and a-quarter above the White-fish River route, the gneiss rises in bold precipitous cliffs about 150 feet high, on the north-west side, striking E. N. E. and W. S. W. in vertical strata; the cliffs run across to a small marshy creek, about a-quarter of a mile above the falls, and present low bluffs or ledges over its southern bank; but about a mile further up, an exposure of quartzite and slate, belonging to the Huronian series, comes to the river dipping N. W. <65°.

The junction of the upper and lower formations must consequently take place in the low marshy ground near the creek; it crosses the river there, but probably extends only a short distance on the other side, for though the exposures on the river up to the northerly turn to Wahnapitaeping are all of the upper series, the strata nearly coincide with the course of the stream, and just at the turn another exhibition of the gneiss of the lower series makes its appearance; a small low hollow or dingle at this part seems to mark the boundary of the formations, the contorted red and grey gneiss being on the south-east side of it, while the north-west is occupied by a somewhat coarse-grained greenstone, which at one part has an arrangement of its crystals in a manner obscurely resembling stratification.

Huronian Series.

It has already been stated that coming from the lower to the higher formations a mass of rather coarse-grained greenstone was generally met with. It was so on each occasion, with the

exception of one, and in that there was an interval between the formations occupied by a marsh, beneath which the greenstone may have been present without any exposure. Whether this greenstone is the result of an overflow contemporaneous with the upper formation, or an eruptive mass intruded at a later period, has not yet been ascertained. Greenstones almost or quite identical with this were found at other parts, forming regular bands between beds of quartzite and conglomerate or slate, and were frequently seen to cap the hills where the strata below were nearly horizontal; but there are also many vertical intrusions where the greenstone presents no distinctive difference in mineral character from the intercalated layers, farther than being generally in a slight degree of a finer grain.

The rocks which form the different members of the group, as seen in the area examined, taken independantly of igneous intrusions or interposed trap beds, may, there is reason to suppose, be found to succeed one another in something like the following ascending order; the district however is so much disturbed that the sequence is not given with much confidence, though all the masses described are met with in one place or other.

1. Fine grained green silicious slates, with thin bands of green quartzite interstratified; also fine grained slates, sometimes of a green tinge, and often bluish or black, weathering very black; occasionally some layers assume a reddish color; copper pyrites and iron pyrites are frequently present in this division.
2. Slate conglomerate, the matrix always greenish in colour; sometimes it has a regular slaty structure, at other times it resembles a massive fine-grained greenstone trap; it holds pebbles of white and red syenite in great profusion, with occasional masses of green, brown and red jasper, rounded in form; associated with the conglomerate, and probably not far from the division No. 1 are green slates in very regular laminæ, cleaving with the bedding, and usually cut by parallel joints.
3. A band of limestone; its strata always appear very much disturbed, and it is in general associated with greenstone. The prevailing color of the limestone when found in mass, is a pale whitish-grey, sometimes passing into dark blue; the band is frequently brecciated, and often displays rough jagged edges, which appear to belong to layers of hornstone: portions of the band are indurated calcareous shale, and these occasionally contain fine-grained silicious pebbles.

4. Slate conglomerate resembling the slate conglomerate on the other side of the limestone.
5. Green silicious chloritic slates, with some tolerably strong bands of quartzite.
6. White and very pale sea-green close-grained quartzite, with beds of quartz conglomerate interposed, and layers of talco-quartzose slate, sometimes of a dark green color, but more frequently a pale flesh-red. The pebbles of the conglomerate are chiefly small white opaque rounded masses of quartz, but these are occasionally mixed with rounded masses of red and green jasper.

Leaving the Laurentian rocks on the main stream, at the junction of the Sturgeon River and the Maskanongi, and ascending the tributary, the range of the greenstone with beds belonging to the first division, consisting of green and bluish slates, sometimes weathering very black, and thin layers of greenish quartzite, were found on the shores of the largest of the three lower lakes; the slates were generally of a very fine grain and compact texture, and frequently contained copper and iron pyrites.

At the head of the same lake the slate, which there is green, weathering brownish-grey, rises in a set of parallel ridges, running N. 50° E. and S. 50° W., the strata apparently vertical. The rock here produces a rough, jagged and wrinkled surface, breaking into elongated splinters when struck with the hammer. Abreast of the falls, at the head of the lake, the slates, otherwise similar to those of the ridge below, and still forming a ridge on the south side, are conglomerate, holding rounded pebbles of syenite, with occasional brown and green ones of jasper.

To the west, the slates are cut off by the intrusion of a dyke of compact flesh-red feldspar, which crosses the portage between the two lakes, at the southern bend, and forms the falls. The intrusive red feldspar was found to be cut by small veins of specular iron ore; and veins of semi-translucent white quartz, holding yellow sulphuret of copper, intersect both, displacing the iron ore veins. The general bearing of the whole intrusive mass appeared to be nearly north and south, but the main vein of quartz, holding copper pyrites, lies about N. E. and S. W. Smaller quartz veins, but apparently without copper ore, run into the main vein on either side.

At the foot of the lake, where a southern bend occurs in the coast, the strata consist of slate and quartzite, very much disturbed; but they shew a general strike nearly east and west, with dykes of greenstone and compact flesh-red feldspar cutting them transversely, till turning north up the long narrow lake below Maskanongi-wagaming, when the slates strike along the east side, shewing a regular dip from N. 80° E. to due east, with an average inclination of twenty-five degrees.

At a short distance west from the lake, the hills are greenstone and pale greenish quartzite, which possibly may be interstratified with one another; but their mutual relation not being well developed, such cannot be asserted as a fact.

At the falls at the foot of the Maskanongi-wagaming Lake, the rock is compact dark blue or greenish slate, and the same rock continues on both sides of the lower bay; but above the lower bay, as far as the head of the lake, the shores and islands are slate conglomerate, with pebbles of syenite. The attitude of the conglomerate on Maskanongi-wagaming appears, for the most part, to be nearly horizontal. On the west side of the lake, it was observed to form the lowest of a set of distinctly marked bands of rock, the accumulation of which constituted the highest hill; it was succeeded above by a band of greenish colored quartzite, some of which has a slaty cleavage parallel to the layers of the deposit, while the third and fourth, or uppermost bands, were found to be greenstone, the dip of the whole being N. W. by W.< from 10° to 12°.

On the east side of the lake, directly opposite this graded mountain, the conglomerate gives an escarpment facing to the west, with an easterly dip, showing that the axis of a gentle north and south anticlinal runs along the lake. At the head of the lake, and abreast of the rapids on the stream above, the escarpment faces easterly, and the rock, being on the western side of the anticlinal, slopes gently to the west.

On the small northern lakes below Metagamashing, and at the lower end of Metagamashing itself, the rock is a very fine-grained finely laminated green slate, portions of which contain rounded pebbles of syenite, remotely apart from each other. At the portages next below Metagamashing, these

slates dip S. 2° W.< from 10° to 15°, but that dip is not constant, as a short distance above they become horizontal. They are divided by two sets of parallel joints cutting the strata into rhomboidal-shaped blocks, the direction of one set being N. 52° W., and the other N. 23° E. The rock being cleavable to an unusual extent, in directions parallel with these joints, may be broken into very small fragments of similar shape. Portions of this slate are tolerably well suited for whetstones.

Both shores of the north-east arm of Metagamashing are of syenitic slate conglomerate, the strata gently undulating, or nearly horizontal, until getting within a mile and a-quarter of the point of the peninsula which divides the two arms of the lake, where the rock is a pale green quartzite, evincing great disturbance, and dipping irregularly to the westward. Above the point where the quartzite appears, the rock is a pale flesh-red syenite, the principal constituent mineral being a flesh-red feldspar, and farther up still, on both sides of the narrows leading to the main body of the lake, it is greenstone.

On both sides of the north-west arm, the rock is white or pale green quartzite, portions having a regular slaty cleavage, parallel with the bedding, which shows a dip all along the west coast from N. 57° E. to N. 75° E., the average inclination being sixty degrees. At the rapids on the river, just above its junction with the lake, there are ledges of white and pale greenish quartzite, holding interstratified layers of white quartz conglomerate, ranging generally N. N. W. and S. S. E.

On the southern portion of Metagamashing, the rock of the coast is chiefly greenstone, with disturbed strata of syenitic slate conglomerate and slate on some of the points and on the islands near the middle. On the group of small islands in the bay leading to the portage over the water-shed, slates and greenstones are seen in interstratified layers, dipping S. 70° E. <45°, and the water-shed is greenstone. It appears probable that the greenstone of the southern bay is a continuation of the intrusive mass of greenstone and syenite observed at the peninsula dividing the two arms of the lake.

At the small lake on the west side of the water-shed, the

rock is a compact dark blue silicious slate, shewing an easterly dip; and the islands in the eastern bay of Wahnapitaeping, as well as the eastern coast of the lake to the south of them, are syenitic slate conglomerate, but the coast on the west side of the bay is greenstone. The greenstone here forms the bold promontory which divides the eastern bay from the main body of the lake, and also the islands off the east coast south from it, running in a direct line S. 22° W. The greenstone of the peninsula is extended to the islands outside of it, and then followed by ridges of slate conglomerate, with a strike parallel to it. This slate conglomerate follows it also on the north-east shore of the lake, where it prevails for the breadth of about a mile, with greenstone again beyond it, in two sharp points, which show a strike N. 30° E.

Between these points and the mouth of the river, there are no exposures of rock on the north shore of the lake; but rocks which would apparently strike into this part, compose the mountain on the west side of the river, a short distance above. The eastern part of them, towards the foot of the mountain, consists of alternations of greenstone and quartzite, running quite parallel to one another, with a strike of S. 45° E. The western part, which is at the summit, is composed of white or very pale sea-green quartzite, with very regular layers of quartzose conglomerate, seldom over an inch or two in thickness, holding small rounded pebbles of white quartz, with some of red jasper. The beds are perfectly vertical, with a strike S. 37° E. The first rock on the lake shore, on the west side of the mouth of the river, would come in considerably to the westward of the mountain strata. It is situated just beyond the delta, and consists of greenstone running apparently N. 16° W.; beyond this greenstone, about half-a mile, there appeared two exposures of green silicious slate, over a mile from one another, the more eastward of which was very pyritiferous; its dip was W. $<45°$, while that of the westward one, which was much disturbed, appeared to be S. 68° E., with an uncertain slope.

At the north-west angle of Lake Wahnapitaeping there is an intrusion of pale flesh-red fine-grained syenite, which, where

seen on the mainland, seems to strike N. 44° W.; but turning more southerly in its opposite course, it runs apparently about north and south, forming portions of the islands grouped across the western bay, and striking the mainland again at the southern point of the same bay. This syenite appears to be closely associated with a great mass of greenstone, which rises in a lofty vertical precipice immediately west from it, and forms the promontory on the south side of the western bay.

Entangled with the greenstone there are masses of rock of a beautifully variegated aspect, having large white and deep flesh-red rounded masses of feldspar, thickly disseminated through a base composed of smaller masses of the same description, with others of translucent quartz, among which a green amorphous mineral reticulates, apparently pyroxene or hornblende, sometimes giving a banded aspect to small portions. Mica is present in small quantity running parallel with these bands. The rock has the character of what by French geologists would be termed an *arkose*. It may be an altered rock, and is not unlike some portions of the gneiss of the Laurentian series, to which it may perhaps belong.

The precipitous hills a little farther south present similar varieties of rock, and on some of the islands and at a point of the mainland masses of altered rock and contorted slate were seen adhering to the syenite, while they were at the same time cut by quartzo-feldspathic veins. The general strike of these slates was N. 32° E. on the island, and N. 28° W. on the mainland.

Beyond this the whole of the west and south shores of the lake display the effect of a very high degree of disturbance, and slates, conglomerates, quartzites and greenstone, with brecciated limestone, come in strangely irregular juxtaposition. Along the western shore and on both sides of the south-western bay, towards its extremity, the exposures are greenstone and altered silicious slates, which have somewhat the appearance of being interstratified with one another; but at the northern extremity of the promontory dividing the south-west from the south-east bay, there is a white or yellowish quartzite, immediately succeeded by a conglomerate containing large

rounded masses of syenite, quartz and jasper, so intimately blended with the paste in which they are enclosed, which is of a green trappean aspect, that except for the smooth polished surfaces, wet from the wash of the lake, revealing the contrast of color, it might be readily mistaken for a portion of the greenstone with which it comes in contact.

Associated with the greenstone which succeeds the conglomerate on the east is a breccia, made up of angular fragments of greenish quartz and very dark grey silicious slate, cemented together in a calcareous paste, the whole mass weathering black. This breccia was observed to skirt the shore, keeping always in contact with the greenstone, for about half-a-mile, leaving it at the north-west point of the promontory on a strike N. 50° E. Outside of the point it bears more easterly, and strikes through the cluster of islets which lie at the point, apparently running straight across the eastern bay.

Re-appearing at the water's edge on the eastern shore, it is overlaid by an altered fine-grained compact silicious slate, which again is overlaid by greenstone, veins of white calcareous spar cutting through the whole series. At this point the breccia is exposed for only a very short distance, striking along the coast at the edge of the water, but it re-appears on a small island about a mile farther north, lying between the string of greenstone islands mentioned above and the eastern shore. Small patches of calcareous material were occasionally found pasted against the greenstone of the islands on the east side, and in the small cracks and fissures cutting the body of the rock, effervescence indicating the presence of carbonate of lime, was sometimes observed on the application of an acid.

The masses along the east coast of the south-eastern bay and of the islands within it, are chiefly quartzite, some portions of which are very pure white, others being grey and greenish, while some are partially of a pink or rose-red. The prevalent dip of all these is easterly. On the western side of the bay a reddish-grey or greenish syenite keeps the shore for about a mile, and probably cuts through the grey quartzites which hold the coast south from it to the outlet of the lake.

On the north point of the island, at the outlet of the lake, a

mass of silicious and pyritiferous slates, interstratified with bands of grey and greenish quartzite, was observed to be cut by a vein of white quartz from five to six yards across. The only metalliferous mineral perceived in it was iron pyrites.

In that part of the Wahnapitae which occurs between the exit of the lake and the western turn, about ten miles below, the course of the river and the stratification appear to coincide, and the rocks exposed at all the rapids in succession are of pretty uniform character, consisting of silicious pyritiferous slates of a greenish color, interstratified with bands of grey and white quartzite. At this turn occurs one of the greenstone masses which have been mentioned as usually interposed between the Laurentian and Huronian series.

For another and almost equal stretch of the river, the stratification of these silicious slates and quartzites coincides with its course, and they compose the rocks of the falls and rapids in highly inclined or vertical strata. At one of the falls the slates are partially micaceous, and split up into long splinters, with a fluted surface presenting a ligneous aspect.

The slates and quartzites, as was stated previously, leave the Wahnapitae about two miles above the sixty-feet fall and rapids, striking south-westerly for the head lakes of the White-fish River. The formation was first recognized after leaving the Wahnapitae at the small lakes on the east side of the water-shed, with a band of greenstone flanking it to the south-east; thence running south-westerly across the water-shed, the outcrop strikes generally in that direction parallel with the course of the White-fish chain of lakes.

The country north-west of the lakes above Round Lake appears to run in ridges parallel with them, and judging by what is seen crossing to White-fish Lake, it is composed of pale yellowish-white and greenish quartzite and silicious slate, interstratified with one another, and of greenstone. The greenstone forms bold, lofty, precipitous and abrupt hills, while the quartzite and slate occupy the lower grounds, and usually come to the shores of the lakes in bold rounded bluffs.

Following Salter's meridian line, about a mile north from White-fish Lake, or within twelve chains of his second mile

mark, after crossing a ridge of greenstone and some low ground beyond, a stream connecting the upper lakes of the White-fish branch of the Spanish River is reached, on the banks of which dark blue silicious slate is exposed dipping at a high angle, S. 5° W. Farther on, after crossing a ridge of slate which rises on the north bank, a ridge of white quartzite crosses the line a little within the third mile mark, and a little beyond the fourth mile mark the rock is red syenite. At the fifth mile a dingy green magnetic trap, with a large amount of iron pyrites, forms a ridge, and that rock, with syenite, continues in a succession of parallel ridges to the seventh mile, beyond which the country becomes low and marshy. These parallel ridges strike nearly east and west, and small brooks or marshes occupy the intermediate valleys.

Previous to my visit to White-fish Lake, I had been informed by Mr. Salter that local attraction of the magnet had been observed by himself, while he was engaged in running the meridian line, and he expressed it to be his opinion that the presence of a large body of iron ore was the immediate cause. When, therefore, I came to the part indicated by Mr. Salter, I made a very careful examination not only in the direction of the meridian line, but for a considerable distance on each side of it, and the result of my examination was that the local attraction, which I found exactly as described by Mr. Salter, was owing to the presence of an immense mass of magnetic trap.

The compass was found while traversing these trap ridges, to be deflected from its true bearing upwards of ten degrees at several different parts, and in one place it shewed a variation of fifteen degrees west of the true meridian, or about twelve degrees from the true magnetic north. Specimens of this trap have been given to Mr. Hunt for analysis, and the result of his investigation shews that it contains magnetic iron ore and magnetic iron pyrites generally disseminated through the rock, the former in very small grains; titaniferous iron was found associated with the magnetic ore, and a small quantity of nickel and copper with the pyrites. It was remarked that notwithstanding the powerful influence of this magnetic mass

in causing a general local attraction, the contact of fragments of it with the compass, although producing a slight effect, rarely occasioned any remarkable agitation of the needle.

The rocks exhibited on the shores and islands of Round Lake and on the south-eastern arm of Lake Panache, are in general character similar to those exposed on the north side of the water-shed at White-fish Lake. They consist of green, yellowish and white quartzite, interstratified with green silicious slates, associated with great masses of greenstone, the latter forming lofty precipices, and abrupt hills running in the general strike. These measures are supposed to be lower members of the formation, brought into the positions they occupy by a series of undulations, of which the water-shed between Muckataewagaming and White-fish Lake is the position of a main anticlinal axis.

Syenitic slate conglomerate was first observed on White-fish River at Lake Panache, not far below the junction of the stream from Lake Lavase, where its characteristics precisely resemble those of the slate conglomerates so widely spread over the valley of the Maskanongi.

At this point it was found in contact with greenstones, but on the south side of the promontory which divides the upper from the south bay, it occurs in low rounded ridges, succeeding hills of green slate, interstratified with beds of greenish and white quartzite.

To determine with certainty the order of succession on the promontory would involve much difficulty, as the rocks are in a state of great disturbance; but it seems probable from the attitude they present, that the green slates, with their associated beds of quartzite, are lower in superposition than the conglomerate, and may be the equivalent measures of the wrinkled slates seen in juxtaposition with the slate conglomerate on the lower lakes of the Maskanongi.

On the north shore of Lake Panache, about midway between the inlet from Lake Lavase and its western extremity, a band of limestone occurs, which where first observed, appears to be both underlaid and overlaid by syenitic slate conglomerate. The mass of this limestone, which measures about sixty yards

across and may be about 150 feet thick, is of a pale grey color on fracture, weathering to a bluish-grey, with thin layers which have the appearance of chert, but are in reality only harder portions of the limestone, weathering quite black. About the base of the calcareous strata some of the beds are blue, holding more silicious matter than the grey beds, while others are of a brecciated character. The beds are all more or less intersected by small veins of fine greenish jaspery-looking trap, which weathers brown or yellowish.

To the eastward of this exposure the only indications observed of the presence of limestone were on the east side of the large island at the entrance of the south bay, and in the peninsula on the north side at the entrance of the eastern arm; in both of these localities small exposures of a black-weathering brecciated rock, which proved to be calcareous, come up in one or two parts, just over the surface of the water. On the island the calcareous rock is overlaid by a black-weathering slate, which, though without pebbles, resembles the matrix of portions of the slate conglomerate. On the peninsula at the eastern arm the brecciated rock comes directly in contact with greenstone.

To the westward the calcareous strata and syenitic slate conglomerate strike along the north shore, and alternately appear on the coast for about three miles, occasionally coming in contact with a great mass of greenstone, which strikes generally in the same direction. The calcareous rock then appears to be cut off by greenstone, which forms the bold precipitous shore of the lake to the junction of the northern arm.

The islands near the centre part of the lake, which lie off the great south bay, are chiefly white or pale green and yellowish quartzite; in the large one nearest the south shore the beds are massive, the rock in some is granular, and occasionally sufficiently coarse to form a fine conglomerate; portions decompose into a fine yellow sand. The dip on the island varies from S. $<45^{\circ}$ to S. 70° W. $<45^{\circ}$, and at one part it is S. 45° W. $<25^{\circ}$. The south shore and the islands off it are quartzite and greenstone alternately, and at the point where

the lake turns south towards the lower expansion, white and yellowish quartzite is cut by dykes of fine-grained greenstone, which run N. E. and S. W.

At the head of the lower south expansion of Lake Panache, the limestones are again seen on both sides, and also on the two islands near the middle, striking about E. by N. and W. by S., and shewing a southerly dip on the north side of the exposures; but the slate conglomerate, with which it seemed to be associated at other parts, only appears on the south side of the large island, lying at the entrance to the northern arm, and between this island and the exposure of limestone on the west side of the bay, there is a point to the north-east of the limestone displaying fine-grained green slate, which, though very much disturbed and intersected by quartz veins, appears to shew a general dip to the north-west.

South of the limestone, the rock at the points and in the small island near the middle of the lake is bluish-grey and whitish quartzite, with thin beds of silicious slate, dipping generally about S. 30° E. $<$53°; and at the falls at the foot of Lake Panache there are strong beds of whitish-grey quartzite sometimes tinged with red, striking N. 50° W. and S. 50° E. in a vertical attitude.

The north shore of the lake below the falls is greenstone, associated with which at one part, a rough black-weathering calcareous mass was observed adhering to the igneous rock, but only for a few yards a little over the surface of the water. Farther down the lake, on both sides, the exposures are white or greenish quartzite, with occasional layers of white quartz conglomerate, all shewing a southerly dip; but on attaining the long narrow westerly reach, the south shore exhibits pale green pyritiferous quartzite in strong compact beds, interstratified with pale green silicious slates and greenish granular quartzose bands, all in very regular strata, dipping S.$<$ from 25° to 45°.

These measures are cut off to the westward by a great intrusive mass of greenstone, a little way above the higher of the two rapids which join the long east and west lakes. On the west side of the dyke, slate conglomerate is found in

detached patches in contact with greenstone, and it forms a ridge across the end of the peninsula, abreast of the upper rapids, while a ridge on the south side of the stream is greenstone. On the little lake to the north, which intervenes between the two rapids, the rock is whitish and pinkish quartzite with silicious slates, striking generally about east and west; the strata sometimes contorted, and occasionally in a vertical attitude.

On the shores of the long narrow lake, west of the lower rapids, the rock on each side is syenitic slate conglomerate; associated with which is a fine-grained green slate, splitting into very regular thin laminæ parallel with the bedding, and intersected by parallel joints. These rocks continue to occupy the coast to the western extremity of the lake, the fine slates occuring only on the south side at one or two places, where they shew a dip S. 7° W. $<65°$. On the north side, immediately north of the slate conglomerate, green and whitish quartzite were occasionally observed, on the surfaces of some of the beds of which a very distinct ripple mark was detected.

The south-flowing stream below the east and west long lake exhibits disturbed strata composed of green silicious slate and quartzite, which at one part, a little above the upper falls, dip to the northward; but farther down measures of a similar character dip to the southward, and at the two falls above the next small lake, the inclination is S. $<65°$. On the north side of the little lake below, the slate conglomerate occurs again, while on the south side, and at the hundred-feet rapids which flow from it, connecting with the lake on the north side of the mountain range, the rock is greenstone. The greenstone here forms a bold ridge running east and west, and is succeeded on its southern flank by syenitic slate conglomerate, and altered green slates, which skirt the north shore; the former to the westward, the latter to the eastward of the junction of the stream. At a bluff point a little way below the end of the portage, on the north side of the mountain lake, a rough black-weathering rock, effervescing with acids, was observed in contact with the greenstone, but the exposure is limited to a few yards of the shore; and its relation to the slate conglomerate, which skirts the shore above and below, could not be ascertained.

The hills which rise on the south side of this lake, and are the eastern extension of the Lacloche Mountains, consist of beds of pure white or pale sea-green quartzite, whitish quartzose slates and conglomerates, and talco-quartzose slates, with bands of greenstone running on the strike. The island in the middle of the lake is quartz conglomerate, which like the talco-quartzose slates at the foot of the mountain on the lake shore, dips northerly, the conglomerate dipping N. 21° W.<65°, the slates N.<75°. The slates and quartz conglomerates higher up the hill strike east and west, and are perfectly vertical.

On the small islet on the eastern arm of the lowest lake, and skirting the north shore of that part of the valley which divides the mountain range, a confused and shattered black-weathering calcareous rock was observed in contact with greenstone, and the rocks on the mountain side north of the greenstone are whitish or pale green quartzose slates and white quartzite, both greenstone and slate striking E. by N. and W. by S., in vertical strata.

The southern division of the range comes out in sections between the lower lake and the lower falls, exhibiting strata identical in mineral character with a large portion of the northern range, white quartz conglomerate associated with quartzose slates, striking the river immediately above the upper falls, with a dip N. 20° W.< from 75° to 80°. Strong beds of white quartzite, some of which are partially conglomerate, associated with greenish-white and reddish silicious slates, occur at the lower falls; the strike of them is about E. N. E. and W. S. W., and they dip at a very high angle to the north. On the shore of Lake Huron, between the mouth of the White-fish River and the Wallace Mine location, the exposed strata are green silicious slate, with strong greenish-grey beds of quartzite, which dip N. W. <60°.

What the total thickness of the rocks of this formation may be, has not yet been ascertained; and no section displaying even an approximation to a regular undisturbed succession has any where been seen. The calcareous rocks will perhaps afford a means by which the structure may ultimately be followed out; but the intrusion of vast masses of greenstone,

dislocating and probably overturning the strata, occasions no small degree of perplexity in investigating the subject, and must give rise to considerable uncertainty in regard to the order of the rocks in detail.

It still remains a doubt in regard to the calcareous deposits, whether they constitute one or more bands of rock. On the lakes at Lacloche, calcareous rocks were found to pass below a considerable thickness of slate conglomerate, whereas on Lake Panache, they are found in apparent interstratification, and at other parts they would appear to be above the slate conglomerate; there may possibly be slate conglomerate both above and below a calcareous band, or there may be two parts of the slate conglomerate, taken as a whole, which are calcareous. In either case calcareous rock would characterise one division of the group.

Assuming this to be the case, and that the quartzose slates, quartz conglomerates, and quartzites of the mountains, are the upper strata of the group, there would then appear to be an anticlinal axis running along the valley between the mountains, on which axis the limestone comes to the surface, and the strata of the hills would be folded up in a synclinal form on each side of it. The limestone and the slate conglomerate come up in the little lake on the north side of the range, and the slate conglomerate is known to run along the shore of Lake Huron, near the outlet of the river on the south.

If this be the structure, the thickness of the quartzose portion at the top would be about 3,000 feet, while the broadest part of the slate conglomerate, as found on the long east and west lake, including the finely laminated slates interstratified with it, the limestone and the green silicious slates above, will give a thickness of at least 2,000 feet. The thickness of the silicious slates with thin interstratified quartzites which occur at the base of the formation, judging from the extent of country over which they spread, is probably as much as the whole of the other parts taken together; so that the vertical thickness of the whole would be about 10,000 feet, which corresponds with what it was supposed to be on the Spanish River.

The accompanying wood-cut, representing a vertical section, illustrates the supposed structure of the Lacloche Mountains at the mouth of the White-fish River.

Drift.

It has already been remarked in previous Reports, that large boulders and rock masses altogether differing in mineral character from the rock formation on which they repose, were observed on the shores and islands of Lake Nipissing, and in the French River below; and that among the most conspicuous of these were huge blocks of conglomerate, and large angular fragments of greenish slate.

That these have been derived from the rocks of the Huronian formation, there can be no manner of doubt, and that the direction in which they have been moved has been southerly. The ruins of the slates and quartzites of the Huronian rocks were observed to be present in the gravel on the banks of the Sturgeon River, from its entrance upwards, increasing in their proportion to the general mass gradually with the ascent, until reaching the valley of the Temagamang, where it constitutes by far the larger portion of the whole deposit.

North Lake. South Lake. Lake Huron.

Scale: 1 3-4 inches to a mile, horizontally and vertically.

a, white and pale sea-green quartzite, with slates and bands of white quartz pebbles.
b, talco-quartzose slates.
c, white quartz conglomerate.
d, white quartzite, with occasional spots of feldspar.
e, green shales and quartzite.
f, upper syenitic slate conglomerate.
g, limestone.
h, lower syenitic slate conglomerate.
i, greenstone.

A, Level of the Sea. B, Level of Lake Huron.

Similar facts were observed in the valleys of the Wahnapitae and French Rivers, where large boulders of conglomerate may frequently be seen to rest on the contorted gneiss at various elevations above the mark of the greatest floods, the highest probably over 100 feet.

The polished surfaces of the rocks of both formations frequently exhibit well developed grooves and scratches, in general nearly parallel to each other, the bearing of which varies at different parts from S. 27° W. to S. 49° W. On the Sturgeon and Maskanongi Rivers, and on Lake Wahnapitaeping, the course of the grooves is S. 27° W., with scarcely any deviation, but farther west they seem to alter their course to a more westerly direction, and on Round Lake they bear S. 41° W.; while at the long lake near the outlet of the White-fish River their direction is S. 49° W.

The great deposits of silicious sand which are spread over the upper valley of the Wahnapitae, above Wahnapitaeping Lake, and also the sand in the valley of the Sturgeon River, are probably chiefly derived from the ruins of the Huronian rocks.

Economic Materials.

The existence of the ores of copper and iron, which are known to be more or less characteristic of the Huronian series of rocks, invests the geographical distribution of the formation with much economic importance. These ores were repeatedly observed in the region explored last season, and although nowhere seen in large amount or to a great extent, the indications were sufficient to establish their pretty general distribution; small specks and patches of the yellow sulphuret of copper were frequently found in the blackish and dark grey slates, on the lower lakes of the Maskanongi; and at the southern turn of these lakes there is a quartz vein of from six to eight feet wide, with copper pyrites, cutting slate conglomerate and an intrusive mass of compact flesh-red feldspar. In the feldspathic dyke, small narrow veins of specular iron ore occur, which appear to run either parallel with the dyke or slightly oblique to it, and the quartz vein and its subordi-

nate *droppers* cut across both. Were this vein as conveniently situated as those of somewhat similar character on Lake Huron, it is fully as well worthy of trial as many that were selected by explorers there, some years ago, upon which to found claims for mining locations.

In the disturbed region surrounding Matagamashing and Wahnapitaeping Lakes, quartz veins are numerously displayed, cutting the syenites, greenstones, slates and quartzites; but with the exception of small specks of yellow sulphuret of copper and iron, they were not observed to contain any metalliferous ores. A much more thorough economic investigation than we had either the means or time to bestow on these veins however would be required, before any satisfactory conclusion could be arrived at as regards their value as lodes.

The magnetic trap discovered on Mr. Salter's meridian line, north of White-fish Lake was observed to hold yellow sulphuret of copper occasionally; and Mr. Hunt's analysis of a hand specimen of the rock, weighing ten ounces, gave twenty grains of metalliferous material, of which eleven were magnetic, and consisted of magnetic iron ore, with a little titaniferous iron ore, and magnetic iron pyrites containing traces of nickel. The nine grains of non-magnetic mineral consisted of iron pyrites, containing from two to three per cent of copper and about one per cent of nickel. Many large quartz veins occur on the lower lakes of the White-fish River, but iron pyrites was the only metalliferous substance which they were observed to contain.

It was reported while I was on Lake Huron, that a charter had been granted to a company to work a certain copper lode, said to exist on one of the promontories immediately west of Shibahahnahning, and that the said company had assumed the title of the Victoria Mining Company. A few specimens of the ore which were presented to me have been submitted to Mr. Hunt for analysis, but as the persons interested in the speculation seemed disposed to conceal the position of the supposed lode, and I had no opportunity of making a personal examination of the ground, I am unable to state further particulars regarding it. The analysis of the ore gave 5.4 per

cent of metallic copper from a fair average specimen of those given me, the pyrites being disseminated through a fine grained grey quartz, but the specimens given me may have been picked samples, and much above the average of the lode.

Of other materials of economic value, the Huronian rocks contain building stone, limestone, slates which in some cases may be used as ordinary whetstones, and in others as scythe-stones; and white quartzite, probably of sufficient purity to be a good material for the manufacture of glass.

For building purposes probably the handsomest and best kinds would be found among the syenitic portion of the formation; the limestone when found in mass, yields a very good material for burning, and is occasionally suitable for ordinary building purposes. An analysis of 100 parts of the limestone taken from the section on the north side of Panache Lake gave to Mr. Hunt the following results:

Carbonate of Lime,	55·10
Carbonate of Magnesia,	6·50
Insoluble sand and a trace of Iron,	38·40
	100·00

A specimen of the limestone at the lower end of Lake Panache, gave:

Carbonate of Lime,	41·97
Carbonate of Magnesia	2·40
Insoluble residue,	55·63
	100·00

A specimen of the limestone from the lower lake near the outlet, lying between the two ridges of the mountain range, gave 36·50 per cent. of carbonate of lime, with a little magnesia.

I have the honor to be,

Sir,

Your most obedient servant,

A. MURRAY,

Assistant Provincial Geologist.

REPORT

FOR THE YEAR 1856,

OF

MR. JAMES RICHARDSON, EXPLORER,

ADDRESSED TO

SIR WILLIAM E. LOGAN, PROVINCIAL GEOLOGIST.

MONTREAL, 1*st* *March*, 1857.

SIR,

Agreeably to the instructions received from you in June last to proceed to the Island of Anticosti, the Mingan Islands, and the Magdalen River, for the purpose of obtaining information regarding their geology, I left Montreal on the last day of the month, and embarked with my assistant, provisions and field equipment, the following day at Quebec, on board of a schooner which reached the west end of Anticosti on the 6th of July.

Through the prompt attention of Mr. Larue, who kindly supplied me with horses and carts, I was at once enabled to land our materials, which without his aid it would have been necessary to carry in single pieces from the boats to the shore, for a-quarter of a mile through the surf, with much loss of time and risk of injury; and I may take this opportunity of stating that I was on several subsequent occasions indebted to him for his attention and assistance.

Not being able to induce the captain of the schooner which carried me to the Island, to convey me to Mingan, where it was my intention to procure men, I was obliged to remain

where I had landed for a few days, until another schooner for passage over and back was procured. While instituting inquiries at Mingan about men, I had an opportunity of making a partial examination of Harbour Island, Large Island, and one point of Mingan Island; and having obtained a boat and two men, with little prospect of obtaining more, the Indians having left for the interior previous to my arrival, we left Mingan on the 16th, and got back to the west end of Anticosti two days after.

While the men were preparing our boat, and re-arranging our provisions for an excursion round the island, I commenced the work of the season by a careful record of the rocks in the neighbourhood, ascertaining the thickness by actual measurement where exposed, and by computation where concealed. When practicable, collections of fossils were made, and their stratigraphical and geographical positions recorded.

On the 23rd July I left the west end, the men proceeding with the boat and provisions to Gamache or Ellis Bay, while I followed on foot; at Gamache Bay I was able to procure a small boat, which was of great advantage in facilitating my work, and by means of it I was enabled to examine the coast and collect specimens all the way to South-west Point, while I was obliged to allow the men to bring on the larger boat with provisions as best they could.

At South-west Point, finding the two men I had engaged at Mingan not suitable for our work, I freed them from their engagement, and hired four others who had two boats of their own, which I also hired, leaving our own boat at South-west Point; I was induced to do this from the consideration that in case of danger the men would be likely to make a greater effort to save their own boats than mine, and in consequence save what was in them. One of these boats was devoted to the carriage of specimens, and the other of provisions and camp equipage.

On the 14th August we left South-west Point, and I continued my examination to the east end of the island, and then along the north coast, keeping always in company with the larger boats, with the exception of ten days at Chaloupe

River, where the larger boats were detained from head winds and storms; while with the small boat and two men I examined the east end of the island, a distance of nearly fifty miles.

Considering on our arrival at Charleton Point, on the 12th September, that the larger boats would no longer be so much required, I sent them on to the west end, where they arrived on the 14th, while I followed and examined the coast with the small one, getting to the same place eight days later. A few days were spent in examining the rocks in that neighbourhood, and making measurements with Rochon's micrometer telescope, so as to determine more minutely the thicknesses of the strata.

But few excursions were made into the interior of the island; they consisted of one at Otter River, for about two miles up; another in the neighbourhood of South-west Point, to the distance of a mile and a-half; a third at Salmon River, for five miles inland; another at Nugg River; and a fifth by Mr. Easton my Assistant, to Marl Lake, three-quarters of a mile.

On the 30th September we left the island in the steamer Doris, for Quebec, with forty boxes and barrels of fossils, and the provisions intended for the survey of the Magdalen River, as well as our camp equipage, making sixty parcels in all, in addition to our small boat. We reached Quebec on the 4th October, and on my arrival at Montreal, on the 7th, on account of the lateness of the season, you recommended the postponement of the survey of the Magdalen River.

On my tour of the coast of Anticosti, I met with much attention and personal kindness from all the officers in charge of the government lighthouses and provision stations. I have great pleasure in having an opportunity of expressing how much I am obliged to Mr. Pope, in charge of South-west Point lighthouse, and to his son, Mr. E. Pope, for the interest they evinced in forwarding the objects of my investigation, and in supplying me with information respecting my excursion round the island, as well as the care his whole family displayed in supplying me with comforts, at the time otherwise beyond my reach. I am indebted to Mr. Corbet, the lessee of the island, and to Mr. Braddley, of Chaloupe River, for their attention;

as well as to Mr. E. Julyan and his family, of Heath Point, in supplying my wants on my arrival there without provisions, my boat having been detained for nearly a week after my arrival, by contrary winds and storms.

In searching for hands to aid me in my work, some difficulty was experienced to procure men acquainted with the coast, notwithstanding that considerable wages were offered; I found none that had been round any considerable portion of the north side, and an opinion appeared to prevail among such as had been for years on the island, in regard to that part, that was anything but encouraging. They seemed to be under the same delusion respecting the north-east coast of Anticosti, that those at a greater distance are in respect to the whole of it.

Since my return I have had an opportunity of reading an article on the resources and capabilities of the island, by Mr. Roche, published in the Transactions of the Literary and Historical Society of Quebec, in 1855; and in so far as I am enabled to judge, find it a correct and unexaggerated statement of facts.

Character of the Country and Coast.

A great part of the coast has a belt of reefs that are dry at low water, while they are covered according to the state of the tide at various depths at high water. The outer edge of these reefs forms a precipice, according to Bayfield, of twenty, fifty and even a hundred feet; they occasionally shelve a little, but generally so little, that vessels approaching the coast have but small intimation of danger from soundings.

These reefs are composed of the argillaceous limestone of the island, and extend out from the shore usually from a-quarter of a mile to a mile; and in one or two instances, to about a mile and a-half. They conform to the bends of the coast, and where bays occur, deep water may be expected to within a-quarter or half-a-mile of the head of the bay, in a line up the centre, usually at about right angles to the general run of the coast.

From the west end, the reefs are continuous on the south side to St. Mary's River, for about six miles to the east of

which, deep water prevails close in shore; from this the reefs again extend to South-west Point, with the exception of a mile before reaching it, and a mile on each side of Jupiter River. From South-west Point they run about four miles to the east, beyond which, to Iron River, only a few points were observed where reefs existed; but from Iron River to Heath Point, and for two miles north-east of it they are very general. On the north side, deep water prevails close in towards the beach, as far as Observation Bay; but from Observation Bay to the west end, reefs are well marked, with the exception of about a mile, rounding North Point.

On the reefs it is not uncommon to meet with boulders, but great distances may be seen without them; where they occur it is generally in considerable numbers, covering patches of from one or two acres up to half-a-mile; they are oftener seen in the bays than in less sheltered places; but North Point would be an exception to this; they are there closely packed together for about half-a-mile, and some of them are of a large size; they belong to the Laurentian series of rocks.

The south side of the island, in its general aspect, is low; the most elevated points close on this coast are at the mouth of Jupiter River, where cliffs rise on the east side to the height of from eighty to a hundred feet; and on the west side to a hundred and fifty feet. On no other part of the south coast were they observed to rise more than from thirty to sixty feet, but the general height above the sea is from ten to twenty feet.

From South-west Point to the west end, the hills inland are more elevated than they are to the eastward; in general they rise gradually and more continuously from the shore, attaining the height of from a hundred and fifty to two hundred and fifty feet, at about the distance of from one to three miles. From this however are to be excepted certain localities on the coast, where plains are met with having a superficial area of from a hundred to a thousand acres underlaid by peat, partly bare of vegetation, but over considerable spaces, supporting a heavy growth of wild grass from four to five feet high.

From a position a few miles east of South-west Point to Wreck Bay, which is at the east end of the island, between

Heath Point and East Point, the elevation of the coast above high water is from seven to fifteen feet, with the exception of the neighbourhood of South Point and Cormorant Point, which rise to the height of from twenty to thirty feet on the shore; but very little rise takes place inland for from one to three miles, and this flat surface is bounded to the north by a gradual slope, rising to the height of from one hundred to two hundred feet, probably becoming more elevated still further inland. The low country is a succession of peat plains, occasionally bare, but often covered with wild grass; the whole being varied with strips and clumps of trees, as well as dotted with small lakes, on which ducks, geese and other wild fowl breed in considerable numbers.

The whole of the north side of the island is a succession of ridge-like elevations of from 200 to 500 feet above the sea, separated by depressions. From English Head, three miles east from the west end to West Cliff, a distance of fifty-eight miles in a straight line, each successive ridge and valley occupies a breadth of from four to six miles; the ridges form a somewhat rounded end, facing the sea on the north; their rise is first well marked at from a-quarter of a mile to a mile from the shore, and in about a mile more inland, they attain their greatest elevation; continuing this elevation to the south and widening, they narrow the intermediate valley, until as far as known, the country becomes in appearance of a gently undulating character. The run of the valleys with some exceptions is from S. 10° W. to S. 30° W.

Macastey Ridge or Mountain, eleven miles east from the west end, rises upwards of four hundred feet at about a mile inland. High Cliff, eighteen miles further east, is probably 500 feet, one quarter of a mile from the shore; these are in some respects the most conspicuous ridges. High Cliff is a bold head-land, while Macastey Mountain is separated by a broader valley than usual from its neighbour to the east, and is higher than any other to the west. Macastey Mountain is a conspicuous object when viewed even from the south side of the island, in the neighbourhood of Ellis, or Gamache Bay; sailing up this natural harbour, it is observed in front a little to the right about five or six miles distant.

The succession of ridge and valley, from English Head all the way to West Cliff, is regular and characteristic, and produces a pleasing and beautiful effect. From West Cliff to Observation Bay, a distance of about twenty miles, there is a similar succession, but on this part the ridges rise to their full elevation nearer to the shore. West Cliff rises immediately over the sea to an elevation of between 200 and 400 feet. Charleton Point has an elevation of 100 feet over the sea, and a-quarter of a mile inland rises to between 300 and 400 feet; from Charleton Point to Observation Bay the coast is somewhat lower, Observation Bay forming an indentation on the coast of a mile and a quarter deep, and five miles across; from the head of this bay a well marked valley bears S. 10° W.

From Observation Bay to Gull Cape, a distance of fifty-three miles, the cliffs become more prominent on the coast, rising almost perpendicularly at the points to the height of from 100 to 300 feet; and the indentations are more numerous, producing more sharply defined valleys.

Between Bear Head and Cape Robert, a distance of five miles and a-half, the greatest indentation from a straight line is about a mile and a-half; but this is subdivided into Easton Bay, Tower Bay, and White Bay, the last being the largest.

Salmon River Bay, east from Cape Henry, is five miles wide, and its greatest depth is one mile. Salmon River runs through a well marked valley, of which the general bearing up stream is S. 65° W. for nearly six miles, where a transverse valley, in the bearing N. 77° W. and S. 77° E. (about parallel with the coast) meets it, and gives it two streams running from opposite directions. From the middle of the valley the land gradually rises on each side to the height of from 400 to 450 feet, and the bed of the valley must rise pretty fast; for though the current of the stream is without leaps, it is rather rapid.

Prinsta Bay, further east, is an indentation of about one mile in depth, with a width of a mile and a-half; perpendicular cliffs surround this bay to the height of from 100 to 150 feet, except at the very head, where two creeks cut through the rock. On the west side of Prinsta Bay is Cape James, 150

feet in height; and on the east is Table Head. Table Head has a face of from 150 to 160 feet perpendicular, and gains almost at once an additional height, from the summit of which there is a gradual descent on the opposite side, the surface forming on that side a rough outline to the valley through which Fox River passes to Fox Bay, which affords the second important harbour on the Island. The upward course of the valley of the Fox River is N. 72° W.

From Fox Point on the west side of the bay to Gull Cape, upwards of a mile on the east side, there is a distance of six miles, in which the coast is low, Fox Point, the highest part of this, not being more than from thirty to forty feet above the sea.

From Gull Cape to Wreck Bay, a distance of eleven miles, the cliffs are in general perpendicular, and from 100 to 130 feet high, gaining but little elevation inland, probably not over 100 feet, while the surface back from them gives as far as observed, a slightly rolling country.

Excepting the valley of Jupiter River, there are no well defined valleys on the south side of the island.

In respect to the soil of the Island, the plains on the south side, as has been stated, are composed of peat, but the general vegetation of the country is supported by a drift composed for the most part of a calcareous clay, and a light grey or brown colored sand. The elements of the soil would lead to the conclusion of its being a good one, but the opinion of most persons, guided by the rules derived from the description of timber which grows on it, would not be favourable, as there is almost a complete absence, as far as my observation went, of the hard-wood trees supposed to be the sure indication of a good settling country.

The most abundant tree is spruce, in size varying from eight to eighteen inches in diameter, and from forty to eighty feet in length. On the north coast, and in some parts of the south, it is found of good size in the open woods close by the beach, without any intervening space of stunted growth; the stunted growth was occasionally met with on the north side, but it is only on the tops of cliffs, and other places exposed to the

sweep of the heavy coast winds, where spruce, or any other tree on the island is stunted. In these situations there is oftentimes a low, dense, and almost impenetrable barrier of stunted spruce, of from ten to twenty feet across, and rarely exceeding a hundred feet; beyond which open woods and good comparatively large timber prevails.

Pine was observed in the valley of the Salmon River, about four miles inland, where ten or twelve trees that were measured gave from twelve to twenty inches in diameter at the base, with heights varying from sixty to eighty feet. White and yellow birch are common in sizes from a few inches to two feet in diameter at the base, and from twenty to fifty feet high. Balsam-fir was seen, but it was small and not abundant. Tamarack was observed, but it was likewise small and scarce. One of our men, however, who is a hunter on the island, informed me he had seen groves of this timber north from Ellis, or Gamache Bay, of which some of the trees were three feet in diameter, and over a hundred feet in height. Poplar was met with in groves, close to the beach, on the north side of the island.

Of fruit-bearing trees and shrubs, the mountain-ash, or rowan, was the largest; it was most abundant in the interior, but appeared to be of the largest size close on the beach, especially on the north side, where it attains the height of forty feet, with long extending and somewhat slender branches, covered with clusters of fruit. The high cranberry (*Viburnum opulus*) produces a large and juicy fruit, and is abundant. A species of gooseberry bush of from two to three feet high is met with in the woods, but appears to thrive best close to the shingle, on the beach, where strips of two or three yards across and half-a-mile long were occasionally covered with it; the fruit is very good and resembles in taste the garden berry; it is smooth and black colored, and about the size of a common marble; the shrub appeared to be very prolific. Red and black currants are likewise abundant; there appear to be two kinds of each, in one of which the berry is smooth, resembling both in taste and appearance that of the garden, the other rough and prickly, with a bitter taste.

Strawberries are found near the beach; in size and flavor they are but little inferior to the garden fruit; they are most abundant among the grass in the openings, and their season is from the middle of July to the end of August. Five or six other kinds of fruit-bearing plants were observed, some of which might be found of value. The low cranberry was seen in one or two places in some abundance, but I was informed that it was less abundant than in many other past seasons. The raspberry was rarely met with.

The most surprising part of the natural vegetation was a species of pea which was found on the beach, and in open spaces in the woods; on the beach the plant, like the ordinary cultivated field-pea, often covered spaces from a-quarter of an acre to an acre in extent; the stem and the leaf were large, and the pea sufficiently so to be gathered for use; the straw when required is cut and cured for feed for cattle and horses during the winter.

But little is yet known of the agricultural capabilities of the island; the only attempts at cultivation that have been made are at Gamache Bay, South-west Point, and Heath Point. South-west Point and Heath Point are two of the most exposed places in the Island; and Gamache Bay, though a sheltered position, has a peat soil; the whole three are thus unfavourable.

On the 22nd July potatoes were well advanced, and in healthy condition at Gamache Bay; but a field under hay, consisting of timothy, clover and natural grass, did not shew a heavy crop. At South-west Point, Mr. Pope had about three acres of potatoes planted in rows three feet apart; he informed me he expected a yield of 600 bushels, and at the time of my arrival on the 5th of August, the plants were in full blossom, and covered the ground thoroughly; judging from the appearance they seemed the finest patch of potatoes I had ever seen. About half-an-acre of barley was at the time commencing to ripen; it stood about four feet high, with strong stalk and well filled ear. I observed oats in an adjoining patch; these had been late sown, being intended for winter feed for cattle; their appearance indicated a large yield.

On the day of my arrival at Heath Point, the 23rd August, I accompanied Mr. Julyan about a mile from the light-house, to a piece of ground composed of yellowish-brown loam, which he had cleared in the wood, and planted about the middle of June with potatoes and peas; of the potatoes he procured a bucket-full of good size and middling good quality. The peas were in blossom, yet a few pods were found to be fit for use. In this patch I discovered three ears of bald wheat, the seed of which had been among the peas when sown; they were just getting into blossom, and probably would ripen; the ear was an average size, and the straw about three and a-half feet high.

I observed frost only once; it was on the 18th September, but not sufficiently severe to do injury to growing crops; and I was informed by Mr. Julyan that the lowest temperature of the previous winter was only seven degrees of Fahrenheit below zero. On the coast, as might be expected, the atmosphere is damper, and the temperature from ten to fifteen degrees below that of the interior, during June, July, August, and September, and probably May and October.

During the three months of my stay on the island, fogs prevailed for ten days, six of which were the 31st July and the 2nd, 3rd, 4th, and 5th of August, while we were at South-west Point; Mr. Pope told me it was an unusual occurrence. I observed that frequent openings in the fog were seen towards the land, leading to the idea that it was less dense in the interior.

I observed some cattle at South-west Point, belonging to Mr. Pope and Mr. Corbet; they appeared to be in good condition, although they had been left to provide for themselves in the wood openings, or along the shore. A horse belonging to Mr. Pope was in equally good condition.

Harbours.

Gamache or Ellis Bay and Fox Bay are the only two harbours on the island that are comparatively safe in all winds; the former is eight and a-half miles from West-end Lighthouse,

on the south side; the latter is fifteen miles from Heath Point Lighthouse, on the north side. From Cape Eagle to Cape Henry, across the mouth of Gamache Bay, the distance is two miles, with a breadth of deep water of three-quarters of a mile, extending up the bay a mile and a-half, while the depth of the indentation is two miles and a-half. Fox Bay is smaller, and has less depth of water than Gamache Bay. The distance across its mouth is a mile and a-half, with half-a-mile of deep water in the centre, extending up the bay nine-tenths of a mile; the whole depth of the indentation being one mile and two-tenths. These two harbours occur in the same geological formation, while the rock presents a very regular and comparatively level surface, over which a road could be easily constructed from one harbour to the other, the distance being 120 miles; by such means the whole island would be brought to within a moderate distance of a road having a natural harbour at each end.

It belongs to an engineer to say how far these natural harbours might be capable of artificial improvement. The belt of reef about a mile wide, that lines the shore within them, is composed of argillaceous limestone, in nearly horizontal beds, which are dry at low water of spring tides. Possibly one mode of improvement might be to make excavations in the limestone to the depth required, and to use the materials thus obtained partly to raise the sides of the excavations high enough for piers, and partly for the construction of breakwaters outside. The depth of water on the reefs at spring tides is about six feet, and the strength of the break-water might be made accordingly. I have been informed that a vessel of 500 tons has been loaded with a cargo of timber in Gamache Bay.

During a heavy wind from the east, while I was at Fox Bay, a schooner ran in for shelter, and appeared to be quite safe. On account of the safeness of this harbour, a provision post was established in it; but since the erection of Heath Point Lighthouse, seventeen or eighteen years ago, it has been discontinued; not a single house now remains, although they appear to have been numerous at one time. I mention this

more particularly as on all the charts I have seen, *Provision Post* still remains indicated there; and it happened in one instance at least, that a vessel was wrecked within sight of Heath Point, but the crew, instead of going to the lighthouse, went straight to Fox Bay, where they confidently expected to find shelter; the consequence was that several of them perished with cold and hunger (the time being the beginning of December) before they could reach the lighthouse at Heath Point. The indication cannot be erased from old charts that may be in the hands of mariners, but I am not aware what means have been taken to make navigators acquainted with the change.

I do not know of any other harbours on the Island that are sheltered from all winds, and it appears to me that from every other position on the coast, any vessel near the shore, down to the size of a schooner, during the existence of one wind or other would be immediately obliged to put to sea; for small boats of from three to ten tons burthen, there are scarcely ten miles of the coast where shelter could not be found by passing up the small rivers at high water; and there are many bays that might perhaps be made safe by excavations similar to those to which allusion has been made.

Rivers and Lakes.

The streams that are met with along the coast are, considering the breadth of the island, very numerous. There is scarcely a mile that is not supplied with its clear stream of water, and every six or nine miles shew one of a size sufficiently large, and with a flow sufficiently constant, to keep machinery going. Waterfalls near the coast often present excellent sites for the purpose. The water of these streams is always more or less calcareous. On the south side the largest rivers are the Becscie, the Otter, the Jupiter, (which is the largest on the island) the Pavillon, and Chaloupe; on the north, the Fox and Salmon Rivers are the largest.

On the south shore numerous ponds and small lakes were seen just inside the shingle beach; towards the east end of the island they occur in the low swampy flat that there runs along

the shore. None were met with farther back, and none were observed on the north side of the island except a few small ponds close to the beach.

Great Salt Lake, Little Salt Lake, Chaloupe Lake, and Lake Lacroix on the south side, and Fox Lake on the north side are in reality lagoons of salt water, the tide flowing in and out and mingling with the fresh water of the rivers.

Most of the streams and lakes swarm with the finest brook trout and salmon trout, and large shoals of mackerel were almost daily observed all around the island. But in my tour I saw no appearance of schooners employed in fishing, with the exception of one at South Point. The only operations I heard of connected with the trade, were carried on at the mouth of a few of the larger streams on the south side and at that of Salmon River on the north by men under Mr. Corbet the lessee of the island, and they were entirely confined to the taking of salmon and salmon trout. Seals were extremely abundant, and but for a few Indians who come over from Mingan in July and August, and take a few of them on the north side of the island, they would be wholly undisturbed. In the bays and more sheltered places round the island these creatures are met with by thousands. It was not uncommon to stumble across one asleep on the beach, when generally it was despatched with a blow or two of our hammers.

Several species of whale were observed to be abundant towards the west end of the island. This must be a favorite resort as they were either seen or heard at irregular intervals day and night. One of them about sixty feet in length, and about fifteen feet above the water's edge was found grounded on the reef in Prinsta bay when we passed on the 3rd September.

The only fishing schooners I saw, with the exception of the one mentioned, were at the Mingan Islands, where twelve or thirteen came to the harbor for shelter during a storm. I was informed by Mr. Henderson, the gentleman in charge of the Hudson's Bay Company's post at Mingan, that they were all from American ports.

Wild Animals.

The wild animals met with on the island as far as I am aware are the common black bear, the red, the black, and the silver fox and the marten. Bears are said to be very numerous and hunters talk of their being met with by dozens at a time; but on my excursion I only observed one at Ellis Bay, two near Cormorant Point, and one in the neighbourhood of Observation Cape. I came upon the last one on a narrow strip of beach at the foot of a high and nearly vertical cliff. Seen from a distance I took the animal for a burnt log, and it was only when within fifty yards of him that I perceived my mistake. He appeared to be too busily engaged in making his morning meal, on the remains of a seal, to pay any attention to me, for although with a view of giving him notice to quit I struck my hammer upon a boulder that was near, and made other noises which I conceived might alarm him, he never raised his head to show that he was aware of my presence, but fed on until he had finished the carcase, obliging me, having no rifle, to remain a looker-on for half-an-hour. When nothing of the seal remained but the bones, the bear climbed in a leisurely way up the face of the naked cliff, which could not be many degrees out of the perpendicular, throwing down as he passed considerable blocks of rock, and disappeared over the summit which was not less than a hundred feet above the sea.

Foxes and martens are very abundant; the marten was frequently heard during the night in the neighborhood of our camp, and foxes were seen on several occasions. Of the silver-grey fox, the skin of which frequently sells for from twenty-five to thirty pounds currency, from four to twelve have been obtained by the hunters every winter. Mr. Corbet the lessee of the island employs several men during that season to hunt these animals for their fur, and I understand he makes some profit by the trade.

I heard of no animals of any other description, with the exception of wild fowl, and I saw no frogs nor reptiles of any description, and I was informed by the hunters that there were none.

Distribution of the Rocks.

The rocks of the island were found on examination to be in great part somewhat different in their general lithological character, as well as in their fossil contents from any that had previously come under my notice. I therefore resolved to separate them into certain stratigraphical groups, leaving the determination of their geological age to future investigation. These divisions in ascending order I shall therefore call,

1. Division A.
2. Division B.
3. Division C.
4. Division D.
5. Division E.
6. Division F.

Division A.

This division of the strata which was the lowest met with, is in its general character an argillaceous limestone; the best section of it occurs in the neighbourhood of English Head at the west end of the island, and the following is a sequence of the beds in ascending order:

	ft.	*in.*
Grey limestone beds of two and three inches thick, interstratified with greenish colored shale; the limestone beds are in places filled with fossils in patches of from two to three feet in diameter, while no fossils would be observed in the same bed for considerable intervals. These fossils consisted of univalve and bivalve shells, and the surfaces of the shale were covered with fucoids. The beds of limestone are hard and compact, and the fossils are in consequence with difficulty got out	20	0
Grey limestones and shales of a similar character	24	0
Grey limestones and shales of a similar character, with the addition of interstratified layers of conglomerate limestone of two or three inches thick, in which the pebbles consist of grey limestone and greenish shale, and measure more in the plane of the beds than transversely to them; the diameter of the largest is about three inches; the pebbles lie in a grey argillaceous matrix	13	0
Grey limestones, shales and conglomerates similar to the preceding beds,	12	6
Grey limestones, shales and conglomerates as before; this part is very fossiliferous	10	0

	ft.	in.
Grey argillaceous limestone, interstratified with greenish argillaceous shale	63	0
Grey argillaceous limestone, and greenish argillaceous shale similar to the last, interstratified with beds of pure limestone, and of limestone conglomerate	86	0
Bluish-grey, hard, brittle argillo-calcareous bed, smooth on the surface, with remarkable impressions like the track of some animal, consisting of two parallel rows of semi-circular pits, each pit of about half-an-inch in diameter and separated from the succeeding one about a-quarter of an inch, the one row separated from the other about half-an-inch, and so arranged that the curves of the pits are on the outside, while the centre of each pit is opposite the interrupted circumference of two pits on the other side; the bottoms of the pits on opposite sides slope away from one another leaving a species of ridge between them; these double rows of alternate pits are usually from about ten to about eighteen inches long and are more deeply impressed at one extremity than at the other; the impressions are so numerous on some parts of the surface that scarcely a square yard was without them	0	6
	229	0

The thickness above given is well exposed in the neighborhood referred to, either on the reef or in the cliff. The strata occupy a breadth of nearly a mile at English Head. Their dip is S., and the slope 234 feet in a mile. The lower beds are in the reef (dry at low water), which is about half-a-mile on the outside of the head; the highest beds are at Otter or Indian Cove, where the stream from Marl Lake empties itself into the sea over the bed holding in such abundance the impressions that have been described.

Following the coast in an easterly direction, the measures appear to coincide with it in a general way for nine miles to the point corresponding with Macastey Mountain; for here the Indian Cove track-bed comes out on the shore with a strike N. 55° E., and is traceable to the east side of Macastey Bay, where, after shewing a sinuosity rudely conforming to the shape of the bay, it enters upon the land with a strike S. 84° E., shewing a dip S. 6° W.$<$ 2½°.

Between this and White Cliff, which is the next point examined on the coast, there is an interval of fourteen miles, along which it is probable the measures nearly coincide with

the general trend of the shore; for while there is a uniformity in the physical aspect of the country facing the sea the whole way, the fossils of the cliff in a hundred feet of thickness resemble those of English Head, and the dip of the strata is S. 10 W. <1° to 1½°.

The same uniformity of geographical aspect is preserved to High Cliff, six miles further, and judging from the identity of some fossils, the higher beds of this division are brought to the shore on the west side of the next bay, though the track-bed was not seen. The dip is here S. 15° W., with the augmented slope of 800 feet in a mile. This increased inclination however is maintained but for a very short distance, and following a bed of shale for a couple of miles, from the west to the east side of the bay, the dip gradually becomes S. 4° W., with a slope of 100 feet in a mile; and while the lower beds were observed to follow the bend of the coast for at least a mile farther, the higher ones gained the land, and were observed about half-a-mile from the shore up Nugg River, the position of which is five miles still further on, where they display a dip S. 14° W.< from 2° to 2½°.

From Nugg River to West Cliff the distance is nineteen miles; the coast is nearly straight and presents no new geographical feature. About five miles before reaching the cliff there is a lower one, exposing about eighty feet, the fossils of which resemble those on the coast of English Head. The strata were seen presenting lines along the face of the cliff about parallel with high water mark, with a slope of one or two degrees inland. Approaching West Cliff from this, two trap dykes were observed on the beach; one of them about half-a-mile west of the cliff, with a breadth of about twenty yards, was visible for 120 yards in a bearing N. 62° W.; the other close by the base of the cliff, with a breadth of fifty yards, was seen for about twenty yards in the bearing N. 47° W. Both dykes were composed of fine-grained greenstone, with whitish feldspar and black hornblende, and neither of them appeared to produce any disturbance of the beds; but at the time of observation the sea was close upon them, and it was not easy to determine much with accuracy. The fossils of the

cliff in which there are 130 feet of strata supposed to belong to this division, resemble those of English Head in species and in grouping, and on the east side of the cliff the dip was determined to be S. 17° W. $<1^\circ$ or $1\frac{1}{2}^\circ$.

Three miles further east, beds of the same general character become exposed in cliffs of from twenty to forty feet high, and in their associated reefs, and were several times repeated with no observed deviation between the strike and the general trend of the coast, to Charleton Point, a distance of six miles more, where the dip was ascertained to be S. 18° W. $<1^\circ$.

At Charleton Point some of the beds are crowded with fossils standing out in bold relief on the weathered surfaces, and well defined forms also were obtained from the debris of the cliff. Of these, six or seven species are the same as species obtained at English Head, but there are many that are different. The same beds are repeated at Spruce Point, about three miles further east, and twice more at points in the six succeeding miles, in which there appears to be little or no change of the dip. This is to the west horn of Observation Bay, and crossing this bay to the east horn, which is Observation Cliff, we find at the very base of it a bed of exactly the same lithological character, and presenting on its surface the same peculiar impressions as those at Otter or Indian Cove. The dip at this spot is S. 13° W. $<1^\circ$, and the strike from it westward would bring the bed a little within the western horn, the distance being six miles, but the track-bed was not there detected.

The distance from Indian Cove to Observation Cliff is eighty-two miles, and the bearing in a straight line S. 81° E. At every point examined in the whole distance, the beds vary but little in their lithological characters from those given in the detailed section at English Head. This fact however is not of much value in establishing the stratigraphical equivalence, as beds not much differing from these are met with in the succeeding division. Nor for the same reason can the general resemblance of the fossils be insisted on, for although there are five or six well known Lower Silurian species at all the points, there are other well known Lower Silurian species that

are present at some points and absent at others, while there are many species which I have for the first time seen, some belonging to the whole distance, and some, as far as yet known, peculiar to different points, and nearly all the species ascend to the succeeding division. The whole means of establishing the equivalence of the strata are thus reduced to the strike and the track-bed, which I conceive to be one and the same bed at both extremes of the line; for while it comes upon the coast in three places, just about where it ought to do in order to be in conformity with the strike, it is accompanied in each case by a bed immediately below containing *Atrypa erratica* of Hall, and a new species of *Cypricardia*, about eighty or ninety feet above, which was found no where else. I have therefore ventured to make the bed a stratigraphical station in the superposition of the beds, and to consider that the western eighty-two miles of the north coast of the island belong to Division A.

Division B.

The rocks which succeed the track-bed at Indian Cove, and extend to what I have previously called Junction Cliff, situated three miles and a-half west of Ellis Bay, compose the next division. They are in ascending order as follows:—

	ft.	in.
Bluish-grey somewhat argillaceous limestone in hard and compact beds of from three to six inches thick, interstratified with partings of greenish shale; towards the top there are thin bands of light reddish-grey limestone, rather purer than those below; some of the beds contain fragments of trilobites and other fossils of which it is difficult to procure good specimens from the hardness of the rock; the surfaces of some of the beds shew fucoids..........	50	0
Grey limestone beds of from three to six inches with shale partings between, much like the preceding in character; the top bed contains numerous beautiful specimens of corals of a pure yellowish-white color standing out in relief on the surface...............	5	0
Reddish-grey limestone in thin beds, holding at the top a characteristic fossil which appears to be a new species of *Cypricardia*........	20	0
Reddish-grey limestone beds with thin greenish shale partings, interstratified at intervals of from three to ten feet with beds of from three to six inches, consisting of conglomerate, the pebbles of which are composed of grey limestone, and are of various sizes up to three inches in diameter, lying flat in the bed in a matrix of grey limestone; many fragments of trilobites are met with in the deposit with other fossils..................................	25	0

	ft.	in.
Reddish-grey limestones, conglomerates and shale partings as before..	16	0
Reddish-grey limestones, conglomerates and shale partings as before..	72	0
Reddish-grey limestones in beds of from six to ten inches, interstratified with conglomerates as before; among other organic remains these beds contain in some abundance a tree-like species of fossil with a rough wrinkled or nodular exterior resembling some kinds of bark, and an irregularly chambered tube in the centre with curved septa; around the tube, the chambers of which are empty, there are arranged numerous concentric layers; the whole of the fossil, including the septa, is composed of a yellowish-white carbonate of lime, crystals of which, in the form of dog-tooth spar, stand out from the walls of some of the chambers; the concentric layers are in some cases partially separated, and the exterior sometimes shews that into such spaces the exterior coating of the fossil has been squeezed down, after being broken; these fossils are of various sizes from three to seven inches in diameter, and one of them of about six inches in diameter shewed a length of five feet; they all lie prostrate in the beds. In addition to these tree-like fossils there are corals of the same yellowish-white color in considerable abundance, with other fossils..	102	0
Grey limestones, conglomerates and shale partings, with similar fossils; a bed at the top contains heads of encrinites in some abundance..	82	0
Grey limestones, conglomerates and shale partings with fossils as before	33	0
Grey limestones, conglomerates and shale partings as before, and in addition to the tree-like fossil, corals and other organic remains, a considerable number of orthoceratites are present, but the hard nature of the beds in which they generally occur makes it difficult to get them out in a good state of preservation................	64	0
Grey limestones, conglomerates and shale partings; in addition to the fossils previously mentioned, there is a greater abundance of spiral shells, chiefly *Murchisonia*, than in any of the beds lower down...	165	0
Measures concealed: the shingle on the beach is largely made up of argillo-arenaceous shale of a greenish tinge mingled with worn fragments of grey limestone; from the fact that this arenaceous shale did not occur at other parts of the beach, and from its easily destructible character, it is probable that the beds from which it was derived constitute a considerable part of the measures concealed..	96	0
	730	0

The distance which this division occupies between Indian Cove and Junction Cliff at the west end of the island, is very nearly seven miles. At the cove the dip is S. 6° W., at West End Lighthouse, S. 10° W., half-way between this and

Junction Cliff S. 10° W.; the average is about S. 11° W., and the breadth across the division in this direction is three miles and four-fifths, which would give an average slope of 190 feet in a mile.

From the position of the track-bed in Macastey Bay, the whole height of Macastey Mountain, 400 feet, would belong to this division; as would probably all the inland elevations visible from the sea as far as Charleton point. The first coast cliff belonging to it in this direction is Observation Cliff, where 350 feet of the base of the division rise at once from the sea.

The dip at the base of Observation Cliff as has already been stated is S. 13° W. $<1^{\circ}$; at the second cliff beyond, it is S. 23° W. $<1\frac{1}{4}^{\circ}$ and at the third S. 13° W. $<1\frac{1}{4}^{\circ}$, the distance of the last from Observation Cliff being about four miles, and the strike of the measures along the coast, as deduced from the above, would carry the track-bed out in front of the third cliff a little more than a mile, while the average slope would place it about 100 feet below its base. In the third cliff there is a height of 250 feet; so that its summit would probably not shew any beds higher than those of Observation Cliff. The distance to the next point is about two miles and a-half, and the strike bears very nearly for it; as the measures gradually diminish in inclination towards Guy Point, which is about the same distance further on, and then become quite flat, it is probable that the base of this cliff is not over twenty feet further in vertical height from the track-bed than the base of the cliff mentioned before.

Guy Point has a height of about 200 feet; its summit therefore will scarcely reach so high in the stratification as that of Observation Cliff. The horizontality of the stratification in Guy Point may extend about half-a-mile at right angles to the general strike further west, and would carry the same beds that are at its base to the base of the next cliff eastward, and this would not bring in a greater amount of additional strata than perhaps thirty feet in the bight of Bear Bay beyond. The base of the cliff leading to Bear Head would thus be about 150 feet over the track-bed.

From Bear Head the coast takes a turn more across the

stratification. The dip at the head is S. 17° W., and the inclination, as determined by tracing a bed round into the succeeding cove, is seventy feet in a mile, which would be the amount gained upon the strata at the base of the next point. It would require another mile across the strata to reach the base of the next cliff, which is Tower Point, and about half-a-mile to reach a position in White Bay beyond, which would be in the strike of the most northern point of Cape Robert; but in this mile and a-half the inclination increases to probably 100 feet in a mile, so that the base of Cape Robert would be about 370 feet above the track-bed.

The dip at Cape Robert is S. 13° W.$<1\frac{1}{4}°$, while that of Cape Henry, about three miles and a-half further on, is S. 23° W. $>1\frac{1}{4}°$, and the base of Cape Henry would probably be thirty feet higher, making about 400 feet above the track-bed. At the base of Cape Henry were met with the first observed examples going eastward along the coast, of the tree-like fossil, occuring 188 feet above the track-bed at the west end of the island; but as their vertical distance at Cape Henry would thus be more than twice as great, it is not improbable that examples of the fossil may yet be found farther west.

Cape Henry has a vertical face of about 300 feet, the whole of which appeared to be calcareous; the summit of the cliff would thus be about 700 feet above the track-bed. Crossing the mouth of Salmon River to Battery Point, the next in succession to Cape Henry, a vertical cliff of about sixty feet in height presents itself, in which the prostrate forms of the tree-like fossil protrude from the cliff in tiers, each fossil presenting a circular extremity, with an orifice in the centre, giving to the cliff the aspect of a battery of guns, which has led to its name.

In the bight of a cove, about two miles east of Battery Point, the limestones are followed by arenaceous shales, and the next point, Cape Joseph, which presents a cliff of 180 feet in height, is probably crowned with them, as in the bight of the cove beyond some sandstones, which I could not approach the coast to visit, give to a cliff the name of Grindstone Cape. These sandstones must run along the coast for about five miles, composing part of the face of Cape James in their course, and

coming to the level of the water in Prinsta Bay; they then strike across this bay and run round the lower part of Table Head, where they exhibit a thickness of about fifty feet. The sandstones then sink beneath the level of the water with a dip S. 19° W. <2°, presenting the following section in ascending order:

	ft.	in.
Greenish-grey, thin bedded, fine grained sandstone, with black and brown mica between the layers; the rock is slightly calcareous,..	7	6
Greenish-grey, fine grained, slightly calcareous sandstone in thin beds,	6	0
Greenish-grey, fine grained, slightly calcareous sandstone, with brown and black mica between the layers, which are from three to ten inches in thickness; one bed of from seven to ten inches thick, is free grained, would make a good building stone, and might probably be fit for grindstones,...........................	5	6
Greenish-grey, fine grained, thin bedded and slightly calcareous sandstone, interstratified with layers of from three to six inches thick, more calcareous from the presence of fossils, chiefly convoluted shells, which are mixed up with small pebbles of white and green quartz, some as large as beans, as well as a few grains of blood-red jasper; mica is present between the layers,................	22.	0
Greenish-grey, fine grained sandstone, with fossiliferous coarse grained layers as before,..	5	6
Greenish-grey, fine grained, slightly calcareous sandstone, in beds of one and two feet, which in some parts run into thin slabs, shewing fossils on their surface,.....................................	6	9
	53	3

The last of these beds would be about 750 feet above the track-bed, and the whole of them probably correspond with the supposed arenaceous beds of the west end section. Division B would thus appear to occupy about forty miles of the coast, with the exception of about two miles in the bight of Prinsta Bay, which is comprehended in the succeeding one.

Division C.

Continuing the sequence of the beds at the west end, where the previous division ended near Junction Cliff, the following constitutes the succeeding division in ascending order:

	ft.	in.
Greenish argillo-arenaceous shale..	1	0
Greenish argillo-arenaceous shale, interstratified with beds of grey limestone of from one to three inches thick; in a two-inch bed, a new species of *Lingula* was observed in abundance; in another encrinites were numerous, with other organic remains, ...	1	6
Yellowish-grey, compact, argillaceous limestone, with few observed fossils, ...	10	0
Yellowish-grey, compact, argillaceous limestone, interstratified with light reddish-grey limestone beds of from one to three inches thick, the surfaces of which are covered with a new species of *Orthis*, (*O. Laurentina*) and other fossils; among the debris of these beds many beautiful detached brachiopoda (*Orthis subquadrata* and others) are met with, with spiral univalves (*Murchisonia*); these are the upper beds of Junction Cliff,........................	20	0
Measures partly concealed, but supposed to be of the same character as the preceding, both lithologically and palæontologically, ...	25	0
Ash-grey argillaceous limestone, in beds of from one to three inches thick, alternating with calcareo-argillaceous shale beds of from five to seven inches; and these two descriptions of beds again interstratified with light grey pure limestone beds of one or two inches; no fossils were observed in this part, ...	6	0
Ash-grey argillaceous limestones and shales, interstratified as before with purer limestones; these beds contain a new species of *Pentamerus* (*P. reversus*), with several gasteropoda and brachiopoda, some of which are new, and *Atrypa marginalis*, for the first time, I believe, met with on this continent; all the species are found preserved in the debris and quite detached, as well as standing out in good relief on small slabs, about one mile east of Junction Cliff, ...	20	0
Ash-grey argillaceous limestones and shales, with purer limestones as before, but the fossils not so well preserved, from the beds being exposed to the action of the sea, ...	10	0
Measures concealed,..	7	0
Ash-grey argillaceous limestones and shales, with purer limestones as before, the fossils not so well preserved, in consequence of the action of the sea; this is a mile and a-half east of Junction Cliff,	24	0
Measures concealed,..	30	0
Light yellowish-grey even bedded limestone, in beds of half-an-inch and two inches, characterized by *Leptæna subplana* in abundance, and one or two instances of a small *Atrypa* probably undescribed, all occuring principally between the layers,...................	3	6
Grey argillaceous limestone..	5	0

Yellowish-white coral limestone, the corals of which consist chiefly of four genera: *Chætetes*, *Favosites*, *Heliolites* and *Catenipora*, and they are aggregated in hummocky masses, often composing one-half or three-quarters of the thickness, being from one to three feet, both

ft. in.

horizontally and vertically, and in some instances six feet horizontally. They are surrounded with an ash-grey argillaceous limestone, and cause the overlying bed, conforming to the hummocks, to have the appearance of slightly undulating strata, ... 4 6

The last bed occurs at Point Laframboise, and the over-lying strata being less extensively developed there than to the eastward, the coral bed was searched for in Ellis Bay, and found nearly two miles to the east on the strike, at Cape Henry, which is the west horn of Ellis Bay, and again at Cape Eagle, the east horn, two miles still farther on the strike. The measures below in ascending order, being the equivalents of a part of those at Point Laframboise, are as follows:—

	ft.	in.
Grey limestone, interstratified with grey calcareo-argillaceous shale, sometimes of a greenish color, the lowest bed characterized by a new species of *Murchisonia* (*M. rugosa*), and the tree-like fossil which has been described as existing in the previous division. This fossil is here of larger size than before observed; one specimen now in the museum of the Survey is ten and a-half feet long, six inches in diameter at the larger end, and but an inch or so less at the other. Some of the fragments of others obtained were found to be ten and even fifteen inches in diameter, and if the length were proportionate must when whole, have been probably over thirty feet in length,..	12	0
Light yellowish-grey limestone, in beds of from half-an-inch to two inches thick, with occasional partings of calcareo-argillaceous shale and abundance of *Leptæna subplana*, and two small species of *Atrypa*, ...	5	0
Yellowish coral limestone bed, as before,..................	5	0
	22	0

The measures above the coral bed, in continuation of the section, are as follows:—

	ft.	in.
Grey limestone, with argillaceous partings; these beds were not continuously examined, but the fossils of some of the beds were *Strophomena depressa*, *Leptæna subplana*, *Ambonychia radiata*, and some undescribed species,................................	62	0
Grey compact argillo-calcareous beds, slightly bituminous, interstratified with argillaceous shales; but few fossils were observed, and such as were seen were obscure; these beds form Bear Head, ...	42	0
Measures supposed to be similar to the last, but not thoroughly examined,..	35	0
	306	6

The dip of these beds at Junction Cliff is S. 13° W.; one mile to the east of it, S. 10° W.; at White Cliff, Ellis Bay,

S. 4° W.; at Cape Eagle, S. 18° W.; at Bear Point, S. 21° W. The average of these would be about S. 13° W,; the inclination is a little over 100 feet in a mile, and the direct distance across the strata is three miles. The distance along the coast occupied by the division extending from Junction Cliff to Long Point is about eight miles and a-quarter.

This division as a whole appears to be softer than the preceding ones; it offers no very remarkable cliffs along the coast on the south side, while Ellis or Gamache Bay is worn out of it, as well as a depression holding Gamache Lake and the creek which empties it at the head of the bay.

On the north coast the rocks of the division are met with in the east part of Cape James, and in the bight of Prinsta Bay, where they succeed the sandstones which have been mentioned, and occupy nearly two miles of the coast. In their outcrop further eastward they crown Table Head and come to the level of the water on the east side of it.

The following is a section of the base of the division at this spot in ascending order, as it rests upon the sandstones of which a section was given in the preceding division:—

	ft.	*in.*
Grey limestone in even beds,	6	0
Grey limestone filled with several genera of corals of a yellowish-white color,	3	0
Grey shale and limestone in patches, interlocking in such a manner as to make the bedding obscure; no fossils were observed,	6	6
Grey thin-bedded fossiliferous limestone, with interstratified shale,	8	0
Grey limestone, with yellowish-white corals,	2	6
Grey yellow-weathering limestone, with yellowish-white corals,	1	9
Grey limestone in thin beds, with thin beds of argillo-arenaceous shale slightly calcareous,	9	0
Grey arenaceous limestone, with small scales of brown mica disseminated through it; at the base it has a mamillated hummocky character, the layers in succession getting thicker and thicker in the centre of the hummocks, which are from three inches to three feet in diameter; the whole bed thins down to a-quarter of an inch in about a-quarter of a mile on the strike, and then thickens again farther on, and this appears to be repeated more than once in the dip and rise as well as the strike; the layers split away from one another in smooth curved forms, but the exterior of the hummocks is rough, being marked with small parallel ridges for short distances, and studded with fossils,	3	6

	ft.	in.
Greenish-colored shale, interstratified with thin beds of grey limestone	17	3
Grey calcareo-argillaceous shale with limestone crowded with corals and the tree-like fossils heretofore described. Both of these kinds of organic remains are so numerous and so confusedly mixed as to give to the whole mass at a little distance the aspect of a breccia, and it can in consequence be traced easily by the eye in the face of the cliff round Table Head, as well as round Cape James, for a distance of six miles on the strike, ...	14	0
Grey compact argillaceous limestone, interstratified with beds of purer limestone of a lighter color, which are however in some parts slightly arenaceous. Numerous fossils were observed in the mass, but they were for the most part obscure. At the base there were *Murchisonæ* of eight or even ten inches long ; *Catenipora* occurred and *Atrypa naviformis* was among the fossils ; about the top of the mass *Leptæna subplana* was in some abundance. A fine collection of fossils from this deposit was unfortunately left behind by the boatmen	110	0
	181	6

The rocks of this section reach the position of the old provision post at Fox River ; between the provision post and the foot of an escarpment south of the lagoon at the mouth of the river, the distance is about a furlong over a mile, across the strata, and the dip of the measures is S. 18° W., with a slope of 100 feet in a mile. This would add to the section about 115 feet, which are concealed under the river and lagoon, making the whole thickness 296 feet.

As is the case in the neighborhood of Ellis Bay, the cliffs composed of the rocks of this division at Fox River are low, not exceeding thirty or forty feet, and the deep excavation forming the harbor is another feature which the two extremities of the deposit have in common.

The escarpment which limits the division south of the lagoon comes out upon the coast about a mile and a-quarter beyond Reef Point, the eastern horn of Fox Bay, and the division would thus occupy a distance along the coast from Table Head of upwards of seven miles.

Division D.

Immediately overlying the upper beds of the last division, as given in the section in the neighbourhood of Ellis Bay,

there occur at Long Point about twenty feet of light grey limestone, in beds of from two to six inches, many of which are crowded with another new species of *Pentamerus (P. Barrandi)*, with but few other fossils, and these beds alternate with others holding *Leptæna subplana*, but in less abundance, a few individuals of *Pentamerus* being associated with them. The dip of the measures is here S. 21° W., with an inclination of 120 feet in a mile. The strike of the base of these measures would carry us to the mouth of Duck River, and we accordingly have there a repetition of them in thickness and in average dip.

Similar beds are traceable to Wall's Cove, and here by means of the reef, a thickness of forty-five feet of the same character can be verified, resting upon strata composing a low cliff lining the bight of the bay; as they contained no observed fossils, they were supposed to form the summit of the previous division. In Wall's Cove, while the strata of Division D. are as much crowded as before with *Pentamerus*, the specimens obtained are of a more perfect description, and a few corals are mingled with them. From Wall's Cove the strike and strata coincide all the way to Becscie River, and here on the reef the thickness of similar strata that were examined amounts to ninety-eight feet, resting, as in the case of Wall's Cove, upon beds of the division C., occurring at the river's mouth. The dip at Becscie River is S. 22° W., with a slope of 120 feet in a mile; the coast east of the river is low, and coincides with the strike corresponding with the dip given, as far as St. Mary's River. Beyond this there are cliffs, but they are composed of clay mixed with limestone gravel, and extend to St. Ann's Cove, the margin of which is low and destitute of rocks as far as the point west of Otter River.

At Otter River the pentamerus beds are again seen, and as the dip is there S. 40° W., with a slope much the same as before, it is probable the strike would nearly coincide with the westward run of the coast to St. Mary's River. It is thus probable that these beds are equivalent to a part of the Otter River section; but between these beds and the next that are seen, less than a mile to the eastward of Otter River, there would

be an interval of about a-quarter of a mile across the stratification, which would give room for thirty feet of strata; but whether this is to be considered a part of the ninety-eight feet measured at Otter River, or an addition to it, I am unable to say. The examination on the reef at Otter River was interrupted by the rise of the tide before we could ascertain the character of all the strata which had been exposed at low water, and as we had not arrived at any beds limiting the upward occurrence of the *Pentamerus*, the whole thickness characterized by its abundance may exceed what I have stated. In the ninety-eight feet, a few feet were allowed for what was seen in the rising water in front of me; if however the whole thickness be called a hundred feet, and the beds in the first exposure east of Otter River be added to it, the following will be the section from the base, in ascending order:

	ft.	*in.*
Ash-grey and light reddish-grey limestones, in beds of from two to six inches thick, interstratified in the upper part with conglomerate beds of the same thickness, at intervals of from two to ten feet; the pebbles of these are calcareous, with a diameter of from one to three inches, and lie flat in the beds; a vast number of the beds are crowded with *Pentamerus Barrandi;* with this however in some beds are associated two or three species of corals, and the *Pentamerus* layers are interstratified with others that shew great numbers of *Leptæna subplana*, and other fossils,....................	100	0
Dark ash-grey slightly bituminous limestone, in beds of from two to six inches, with calcareo-argillaceous partings, weathering light orange-brown; conglomerate layers with limestone pebbles occur at irregular intervals; the lowest six feet are characterized by the occurrence in some abundance of a new species of *Atrypa*, and *Strophomena alternata* is frequent in the deposit, with *Orthis* and other fossils, ...	20	6
Dark ash-grey slightly bituminous limestone, with calcareo-argillaceous partings, weathering light orange-brown, similar to the preceding,..	34	6
Dark ash-grey slightly bituminous limestone, as before with but few fossils, ...	36	0
Reddish-grey limestone, in beds of from one-quarter of an inch to three inches, some of which weather to a reddish-brown, interstratified with occasional conglomerate layers of from two to four inches thick; some beds at the base of the deposit are characterized by a species of *Syringopora*, resembling *S. bifurcata*, and by deep serpentining grooves of about a quarter of an inch wide, with		

	ft.	in.
raised edges, apparently marking the track of some species of mollusk; other fossils occur in other parts, and the middle of the deposit is marked by the presence of *Strophomena alternata* in considerable numbers, ...	43	0
Reddish-grey limestone, weathering reddish-brown, in beds of from one to three inches, interstratified with occasional conglomerate beds of from three to six inches thick. Among the fossils which are met with are *Strophomena* and *Favosites*, ...	30	0
	264	0

The last 164 feet of the previous section are ascertained by actual measurement of the beds as they accumulate on one another, going east along the coast for about two miles, in a direction oblique to the stratification. The dip at the commencement was S. 33° W., and at the end S. 40° W., and the inclination is estimated to be about 200 feet in a mile. Carrying on the last dip to the next exposure, which occurs at the distance of a mile further east, it is estimated that there is a thickness of about twenty feet of strata wanting between the two. The cliff then presents thirty-four feet of grey limestone, weathering yellowish, and containing but few fossils. The surface of one bed towards the middle of the mass is characterized by a peculiarity which is probably the result of weathering. The bed is about a couple of inches thick, and is worn into a multitude of rather deep connected pits about an inch across and two or three inches long, in each of which is perceived a fragment of a shell standing with its edge up. There is a general rude parallelism in the pits, but some of them cross others, and some descend nearly through the bed.

In the exact strike of this cliff, as decided by the run of single beds which can be seen for nearly a mile along this reef, another cliff occurs at nearly twice that distance, with a lithological aspect similar to the last, but with a rather larger number of fossils. The base is marked by *Atrypa congesta*, and some of the beds higher up by an *Orthis* resembling *O. Laurentina*, and by a species of *Favosites*. The beds of this cliff are supposed to be included in those of the previous one.

To the next exposure there is a distance of something less than a mile, and from the strike of the strata it is computed

that in the intermediate parts there are concealed about seventeen feet, reaching to the base of the cliff in which the exposure occurs. The cliff, which is forty feet high, occupies about two miles and a-half of the coast, and for two-thirds of the distance the strata appear to be horizontal, then turning down with a gentle slope to give an addition of twenty-five feet in the remaining third. The following section gives the details of these sixty-five feet in ascending order:—

	ft.	in.
Light-grey bituminous limestone, in beds of from one-quarter of an inch to ten inches thick, weathering yellowish-brown in some parts, and holding *Atrypa reticularis* (its first appearance) and numerous remains of *Crinoidea*, and several species of turbinated corals,	10	0
Light smoke-grey, slightly bituminous limestone, more argillaceous than the last, weathering to a yellowish-brown, in beds of from one to two inches, without observed fossils,	5	0
Light grey bituminous limestone, similar to the lowest beds, with *Murchisonia* and other fossils,	5	0
Reddish ash-grey argillaceous limestones, slightly bituminous, in beds of from half-an-inch to ten inches, with abundance of slender serpentining fucoids of a dull yellowish-white, very conspicuous from the contrast of color; *Strophomena alternata* also occurs...	20	0
Light smoke-grey limestone, in beds of from one to ten inches, with the tree-like fossil and ascidians in the lower beds, and in others *Catenipora escharoides*, with the genera *Favosites*, *Pleurotomaria*, *Murchisonia*, *Orthis*, *Leptæna* and *Atrypa*. Some of the beds at the top are ash-grey in colour	25	0
	65	0

Between this cliff and what is considered the base of the succeeding division, the dip of the strata would bring in about twenty-seven feet, which are concealed. The total thickness of the division would thus be:—

	ft.	in.
Pentamerus beds and Otter River section,	264	0
Measures concealed,	40	0
Table River section,	34	0
Measures concealed,	17	0
Two-mile Cliff section,	65	0
Measures concealed,	27	0
	447	0

The rocks of the division reach to within about a mile of the mouth of Jupiter River, and the total distance which they occupy on the coast from Long Point, is upwards of thirty-six miles.

The rocks on the north side of the island at the east end, which from their position in the succession there, are supposed to represent this division, have been as yet too imperfectly examined to enable me to speak with confidence in respect to their volume; nor has anything very striking been observed to establish their exact equivalence, so that it is from the relation they bear to what is below and what is above, rather than from what the north and south localities have in common, that the strata are given as representatives of one another. On the north coast they occupy ten miles, and deep water prevails along the whole of it; in most places the sea beats against the cliff at high water, and in some even at low water, and there are but two or three coves at which a landing can be easily made; it would require very calm weather to effect a thorough examination. With perfectly calm weather, however, every bed in succession might be investigated, as none are concealed in the whole distance. At the time of my visit to the locality there was a considerable stretch of the cliff which we durst not allow our boat to approach, and it was only at the two extremities that admeasurements were made.

Commencing at the base the first disappointment experienced was to find scarcely a trace of the pentamerus beds, so conspicuous on the south side; for with the exception of a single valve of a *Pentamerus*, resembling *P. Barrandi*, not a specimen of the species was met with; instead of it a species of *Atrypa*, resembling *A. robusta* of Hall, prevailed in great abundance, no example of which again was found on the south side. The following is the section obtained at Gull Cape, beginning at the escarpment which has been mentioned as coming to the coast south of Reef Point, where the previous division terminated; the beds are given in ascending order:—

	ft.	*in.*
Lead-grey limestone, in thin beds, interstratified with greenish calcareo-argillaceous shales, slightly arenaceous, and both limestone and shale slightly bituminous; the only fossil observed in it was an *Atrypa*, but not in great abundance,........................	19	0

	ft.	in.
Lead-grey limestone, with no observed fossils,	0	9
Greenish arenaceo-argillaceous shale, slightly calcareous as well as slightly bituminous, crowded with an *Atrypa* (resembling *A. robusta* of Hall); the shale, on exposure to the weather, exfoliates and crumbles, and the fossils, being hard limestone, are easily obtained in a perfect condition,	25	0
Greenish arenaceo-argillaceous shale of the same character as the last, with a variety of the same *Atrypa* as the last, much larger in size; one valve of a *Pentamerus* was met with so much resembling *P. Barrandi* as to leave little doubt that it is the same species, though rather larger than any met with on the south side of the island,	5	0
Light yellowish-grey bituminous limestone, in beds of from half-an-inch to two inches, holding *Atrypa*,	20	0
Dark grey slightly bituminous limestone, in beds of from one to three inches, and towards the top six inches, separated by partings of greenish calcareo-argillaceous shale; fossils weather out in good relief on the surfaces, the most prevalent being *Orthis*,	38	0
Dark grey slightly bituminous limestone, in beds of from three to nine inches, resembling the previous mass, but without observed fossils,	20	0
	127	9

This section was obtained by the measurement of accumulating strata in the cliff as far as Gull Cove, where the highest bed was about sixty feet above high water mark, leaving sixty-seven feet as the thickness that had been passed over at the water's edge. The dip was S. 28° W., and the distance across the measures was three-quarters of a mile, so that the inclination was about ninety feet in a mile; this inclination would carry the sixty feet that are in the cliff to the level of the water in a distance of fifty-three chains in the direction of the dip, and following the strike to the westward, it would come out in Sand-top Bay, where the dip is S. 38° W., at such a distance from the bight of it as would give eighteen feet to the foot of the cliff there. The following section obtained in the cliff gives the details of the succeeding sixty feet in ascending order.—

	ft.	in.
Yellowish-grey, compact, slightly bituminous limestone, in beds of from two to four inches, with few observed fossils, with the exception of three inches at the top, which are a mass of *Murchisonia*, resembling *M. gracilis*, with a few instances of *Orthoceras*, and one or two examples of *Pentamerus*, resembling *P. lens*,	20	0

	ft.	in.
Yellowish-grey slightly bituminous limestone, in beds of from half-an-inch to three inches in thickness, with occasional partings of yellowish-grey calcareous shale; the surfaces of the beds are fossiliferous, and among the fossils are *Calymene Blumenbachii, Orthis, Murchisonia* resembling *M. gracilis*, and *Crinoidea*,.......	15	0
Yellowish-grey, interstratified with greyish-yellow slightly bituminous limestone, in beds of from half-an-inch to two inches, with partings of calcareous shale. The surfaces of the beds shew fossils, among which are *Pentamerus* resembling *P. lens*, *Murchisonia* resembling *gracilis*, *Leptæna* resembling *subplana* but rather more convex, with *Crinoidea*,..............................	15	0
Yellowish-grey and greyish-yellow limestone, as before, with the same fossils as the last, with the addition of *Calymene Blumenbachii, Atrypa congesta*, and other small species, with turbinated corals,.	10	0
	60	0

In Sand-top Bay the dip as has been stated appears to be S. 38° W., and in this direction the top of the preceding section would be carried about fifty-three chains before reaching the level of the sea; following the strike to the eastward, modified by that of Sand-top Cape, the dip there being S. 23° W., the top of the section would come upon the coast in a position which would be just a mile across the measures, from the bight of the bay inside of East Point. The inclination approaching the bight of the bay appears to increase considerably, and by the impression made on the eye by the strata, as seen in the cliff from the boat, I am inclined to think it would be as much as 200 feet in a mile, which would thus be the interval up to the base of the cliff where the next measurement was taken.

From a sudden change, however, which appears to occur in the dip, which becomes S. 3° E., it is not impossible that some dislocation may occur to trouble the calculation. Leaving out this consideration, the following would be the remainder of the beds belonging to the division in ascending order:—

	ft.	in.
Ash-grey limestone, in beds of from half-an-inch to three inches, with calcareo-argillaceous partings, interstratified with iron-grey limestones of the same thicknesses. The condition of the weather was such at the time of my visit that it allowed me to examine the upper five feet only, in which there was displayed in considerable abundance a *Cythere* about half-an-inch long, ...	50	0

	ft.	in.
Yellowish-grey slightly bituminous limestone, charged with a multitude of corals, consisting of the genera *Catenipora*, *Favosites*, *Heliolites*, *Chætetes*, *Cyathophyllum*, and *Orthis*; on the surface, the bed assumed a hummocky character, some patches of the corals rising from one to five feet high, with the diameter of from two to ten feet, the overlying bed conforming in some degree to the inequalities, and giving the strata the aspect of having been disturbed, ...	25	0
	75	0

The coral bed was followed round the coast from the cove to the eastern extremity of East Point, where it sinks beneath the level of the sea, and was taken for the limit of the division D in that vicinity.

The whole thickness of the division on the north coast would thus be as follows:—

	ft.	in.
Gull Cape section, ...	127	9
Measures not examined, ...	18	0
Sand-top Bay section, ...	60	0
Measures not examined, ...	200	0
East Point section, ...	75	0
	480	9

Division E.

The rocks forming the next division commence where those of the previous one terminated, rather more than a mile westward of the mouth of Jupiter River, and occupy the coast between that position and South-west Point, the distance being a little over seven miles, in a direction very nearly S.S.E. The dip of the strata is very constant in its direction, not varying more than about five degrees at any part, the average being S. $7\frac{1}{2}^{\circ}$ W., while the inclination is sometimes 200 feet in a mile, and at others is quite inappreciable. With the exception of some concealment at the base, and more towards and at the summit, the measures are visible all the way, forming cliffs of from twenty to one hundred and fifty feet.

The following is the sequence in ascending order, of the deposits, from a measurement of each bed in succession as it came upon the one beneath, with the exception of the parts concealed, which were determined by computation:—

	ft.	in.
Measures concealed,	27	0
Greenish-grey and brown arenaceo-argillaceous shales interstratified, of a fine texture in thin beds, with no observed fossils,	60	0
Yellowish-grey and light drab argillaceous limestone, slightly bituminous, in beds of from one to five inches, cut by parallel joints running N. 85 W., with an occasional joint running oblique to that course; the jointed structure and the general soft nature of the rock cause large masses to fall from the cliff by the action of the sea, which is encroaching rapidly on the laud. Among the fossils, which are generally in a good state of preservation, there are *Graptolithus* within about twenty feet of the bottom, *Favosites*, *Atrypa reticularis*, and another resembling *A. tumida*, *Pentamerus*, like *P. lens*, *Myolina*, *Cyclonema*, *Orthoceras*, *Cyrtoceras*, *Calymene Blumenbachii* and *Bumastes barriensis*,	80	0
Light drab argillaceous limestone, slightly bituminous, weathering white, interstratified with yellowish limestone, weathering yellowish-brown, both in beds of from two to three inches thick. The fossils are not numerous, but weathered surfaces present well preserved specimens of *Atrypa reticularis*, *Leptæna subplana*, *Calymene Blumenbachii*, *Lychas*, *Phacops*, *Pentamerus lens*, crinoidal columns, and other species,	22	6
Ash-grey and light drab limestones interstratified, both slightly bituminous and in beds of from half an-inch to two inches. The surfaces weather nearly white and shew fossils of which a large number are weathered nearly black, by contrast presenting distinct and well defined forms; among them are *Atrypa reticularis*, *Leptæna subplana*, *Strophomena depressa*, *Pentamerus lens*, *Calymene Blumenbachii*,	42	6
Ash-grey and light drab limestones interstratified, both slightly bituminous, in beds of from two to three inches, holding in the upper part in some abundance, *Pentamerus lens*,	10	3
Ash-grey and light drab limestones interstratified, both slightly bituminous and crowded with *Pentamerus lyratus*,	2	6
The position of this bed is just west of the last brook but one, approaching South-west Point.		
Measures concealed,	25	0
Light drab argillaceous limestone, slightly bituminous,	1	0
Measures concealed,	25	0
Light drab argillaceous limestone, slightly bituminous, in beds of from half-an-inch to three inches, containing numerous fossils, of which weathered surfaces present excellent specimens weathered black, while the edges of the beds along the cliff yield others quite free from the rock. Among the fossils are various corals, with *Atrypa reticularis*, *A. congesta*, *A. hemispherica*, *A. naviformis*, *Spirifer radiatus*, *Leptena subplana*, *L. transversalis*, fragments of *Orthoceras* and *Cyrtoceras*, *Calymene Blumenbachii*, *Phacops* (a new species) and an *Encrinurus*,	87	6
The position of this deposit is a little east of the last brook, approaching South-west Point.		

	ft.	in
Measures concealed at the bight of the cove, north of South-west Point	157	6
	540	9

The rocks at the east end of the island supposed to be equivalent to these, are seen in the section displayed there in continuation of what has already been given to the top of the coral bed at East Point. They are in ascending order as follows:—

	ft.	in.
Yellowish-grey slightly bituminous limestone, withont any well defined bedding, in some measure filling up the inequalities on the top of the coral bed. The rock breaks easily in the plane of the beds with a conchoidal fracture, and is crowded with well preserved fossils, principally *Atrypa hemispherica*, and *Leptæna subplana*; the thickness of the mass is from two to six feet..................	4	0
Bluish-grey argillo-calcareous shale, holding iron pyrites in some abundance..	0	2
Dull ash-grey argillo-calcareous shale, containing no observed fossils, interstratified with patches of drab colored argillaceous limestone, slightly bituminous, in beds of from one to two inches thick, occurring at intervals of from one to four feet; on the surfaces of these, fossils in good preservation are met with, but not in large numbers; among them are *Atrypa reticularis*, with another species, *Leptæna*, *Calymene Blumenbachii*, *Orthoceras*, *Murchisonia*, and various corals..	42	0
Light smoke-grey limestone, slightly bituminous, interstratified with drab-colored soft argillaceous limestone, in beds of from half-an-inch to two inches in thickness. The harder beds occasionally weather to a somewhat brown colour on the surfaces, and present well-preserved fossils weathering blackish-grey, affording superior specimens for the examination of structure. Among the fossils are *Atrypa reticularis*, *A. congesta*, *Leptena subplana*, *L. transversalis*, *L. profunda*, *Spirifer modestus*, *Calymene Blumenbachii*, *Encrinurus*, *Lychas*, *Favosites*, small *Bryozoa*, and crinoidal columns..	75	0
Light smoke-grey slightly bituminous limestones, with drab-colored soft argillaceous limestones, similar in lithological character and in fossils to the last..	20	0

The preceding part of the section is measured at high water mark across the measures from East Point, the dip being S. 18 W., with an ascertained inclination of a little over 100 feet in a mile. The distance at right angles to the strike is two-fifths of a mile.

Measures concealed by the shingle of the beach, which consists of light smoke-grey limestone, mingled with light drab compact argillaceous limestone, both slightly bituminous, pieces of which shew

	ft.	in.
among other fossils *Atrypa reticularis*, *Calymene Blumenbachii*, *Pentamerus*, resembling *P. lens*, with various corals and broken encrinites	85	0
Measures concealed	24	0
The top of these measures reaches a position a little over half-a-mile from Heath Point lighthouse.		
Light smoke-grey slightly bituminous limestone, interstratified with reddish-drab argillaceous limestone, also slightly bituminous, both in beds of from one to three inches, occasionally presenting surfaces, on which are weathered out well defined fossils; among them are *Atrypa reticularis*, *Leptena subplana*, *Pentamerus* resembling *P. lyratus*, with small turbinated corals	75	0
The top of the previous beds reaches the southern promontory of Heath Point upwards of half-a-mile S. S. W. from the lighthouse. The dip of the measures in this neighborhood is S. 18 W., and the inclination was ascertained to be eighty feet in a mile, which is the rate allowed for the last three measurements; the distance which the whole occupies at right angles to the strike being two miles and twenty-four chains.		
In the bight of the bay west of Heath Point some of the last beds are repeated, but carrying the strike from the eastern horn of the bay to the coast on the opposite side, the following are the beds that occur in continuation of the section:—		
Light smoke-grey limestone, slightly bituminous, interstratified with light reddish-drab, similar to the last beds, with similar fossils	33	9
Measures concealed	9	0
In the two preceding measurements the dip is S. 53 W., and the inclination forty-five feet in a mile, as determined by the first; the distance across the measures is seventy-six chains.		
Light smoke-grey and reddish-drab limestones interstratified, similar in lithological character and fossils to the last beds described	15	0
Pale drab colored limestone, interstratified with limestone of a more argillaceous character, and of a somewhat darker color, both in beds of from half-an-inch to three inches thick; the surfaces of these afford beautiful and finely preserved fossils, well weathered out, among which are *Atrypa reticularis*, *A. hemispherica*, *Leptæna*, *Pentamerus* resembling *P. lens*, *Calymene Blumenbachii*, *Encrinurus*, tentaculites, crinoidal columns, and small *Briozoa*	15	0
Ash-grey limestone in beds of from one to six inches, with thin argillaceous partings; some of the beds are crowded with *Pentamerus oblongus*, and *Atrypa reticularis* is common	30	0
The distance across the measures occupied by the last three deposits is sixty chains, and the dip is S. 18 W., with an ascertained inclination of eighty feet in a mile; the dip then changes, approaching a dislocation which occurs at a projecting point, about a mile and three-quarters north-eastward of Cormorant Point.		

	ft.	in.
The course of the fault is N. 37 E., and it produces an upthrow on the west side of forty-five feet, by which the last two measurements are repeated. The sequence of the beds beyond these is as follows :—		
Ash-grey limestones in beds of from one to nine inches, with thin argillaceous partings; some of the beds are filled with *Pentamerus oblongus*, and *Atrypa reticularis* is very frequent	78	0
This deposit reaches to the north side of Cormorant Point; the dip of the measures is S. 20 W., and the ascertained slope is 110 feet in a mile.		
Ash-grey limestone, in beds of from one to six inches thick, interstratified with greenish argillo-arenaceous shale, slightly calcareous, in beds of from an-eighth to a-fourth of an inch thick; in the three feet at the base, it is in patches of from six inches to one foot thick. Among the fossils are *Zaphrentis bilateralis*, *Stromatopora concentrica*, *Favosites favosa*, *Graptolithus*, *Orthoceras* and *Pentamerus oblongus*	45	0
This composes a cliff of from twenty to thirty feet high round Cormorant Point, with a dip S. 18 W., and an inclination ascertained to be eighty feet in a mile, for a breadth across the measures of forty-five chains.		
	550	11

Eastward from Cormorant Point, the measures are concealed for about three miles, and beyond this all the way to Chicotte River, a distance of about fifty miles, there are occasional exposures of limestone, with intervals of concealment, some of which are very long. All the exposures are supposed to belong to this division, but though the beds in no case shew a great inclination, and in several are quite horizontal, the bearings of the dips that are presented vary frequently and considerably, either through small faults or gentle undulations, and it has been found impossible to say with precision to what parts of the division these beds are equivalent, or whether some of them may not add a few feet to the thickness given.

Before describing the positions of these exposures, however, it will be convenient to give a section of the succeeding division.

Division F.

In immediate sequence to the concealed measures which constitute the upper part of the Jupiter River section of the last division, the following beds present themselves in ascending order, and form the whole of the area of what is called South-west Point.

	ft.	in.
Light smoke-grey limestone, of a somewhat granular character, in beds of from three to six inches thick, with thin partings of green argillo-calcareous shale occurring in patches. Iron pyrites is disseminated through the beds, sometimes in single cubes, and sometimes in aggregations of minute cubes forming nodules of from one to two inches in diameter, discoloring the rock by their decomposition. The ruins of crinoidal columns constitute the organic remains..	3	9
Light smoke-grey limestones, with iron pyrites in some abundance, in nodules as before of from half-an-inch to an inch in diameter, and occasionally on the surface of the bed in patches of from half-an-inch to an inch and a-half thick, and from six to eighteen inches in diameter. Fossils occur in fragments but they are too obscure to be identified	0	6
Light smoke-grey limestone of a granular character, in beds of from two to six inches thick, with partings of green argillo-calcareous shale, which also occurs in patches in the beds, giving them a greenish cast; among the fossils occur *Zaphrentis*, like *Z. bilateralis* of Hall; *Stromatopora concentrica*, *Cyathophyllum*, *Atrypa reticularis*, *Pentamerus oblongus*, *P. lens*, *Orthoceras* and crinoidal columns	7	6
Yellowish or reddish-white granular limestone, with thin vein-like patches of argillo-calcareous shale disseminated through it; the beds are from three to seven inches thick. Among the organic remains, several of which are similar to those of the preceding deposit, *Plycliophyllum* characterizes the present one, some of these being a foot in diameter. *Favosites* also occurs in tables of half-an-inch thick, and sometimes three feet in diameter........	7	6
Yellowish-white granular limestone, in beds of from six to eighteen inches thick, often separated by thin partings of green argillo-calcareous shale, which is also disseminated in small patches through the bed. The fossils are few in species, being chiefly the ruins of crinoidal columns, which in some cases form the entire mass of a bed..	20	0
Yellowish-white granular limestones, in beds of from six to twelve inches thick, shewing less green shale than before. The beds are well stored with the fragments of crinoidal columns, which almost entirely compose some of them..............................	14	0

Shortly before reaching the upper part of the previous deposit several small undulations occur in the strata, but the effect of them being visible, allowance has been made for the repetitions they occasion.

The remainder of the section being taken from a part where the effect of the undulations is not so easily followed, the sequence is not so certain.

Yellowish-white granular limestone, in beds of from six to twelve inches thick, consisting of a mass of organic remains, of which crinoidal columns constitute by far the larger part; but other

	ft.	in.
fossils are met with, among which are *Catenipora escharoides*, *Favosites*, *Cystiphyllum*, *Atrypa reticularis*, *Cyrtia*, two species of *Cyclonema*, *Bumastes Barrienses*, *Spherexochus*	4	6
Yellowish-white limestones, in beds of from twelve to eighteen inches thick; the surfaces of some of the beds shew crinoidal columns well weathered out, some of which are three-quarters of an inch in diameter. Among the fossils are *Favosites*, *Catenipora escharoides*, *Atrypa reticularis*, and two species of *Cyclonema*...............	11	6
South-west Point Lighthouse stands on the beds last given.		
	69	3

This is the highest series of strata met with on the island, and its lithological character is so well marked that it is scarcely possible to mistake it for any of those which preceded. Proceeding eastward from South-west Point about three miles, to a place called the Jumpers, a cliff of about thirty feet in height presents itself, where it appears to me probable the junction of the Divisions E and F is seen, the base belonging to the one and the summit to the other. The beds in ascending order are as follows:—

	ft.	in.
Light grey argillaceous limestone, slightly bituminous, in beds of from half-an-inch to three inches thick, interstratified with greenish colored shale; among the fossils observed, *Pentamerus oblongus* and *Atrypa reticularis* were the most abundant................	8	6
Greenish calcareo-argillaceous limestone, slightly bituminous, in beds of from half-an-inch to two inches thick; the shale constitutes about two-thirds of the mass, and crumbling in the atmosphere, allows the exposure of well defined fossils in high relief on the surfaces of the limestone beds. Among the fossils in addition to corals, briozoa, crinoidal columns, and tentaculites, are *Atrypa reticularis*, *A. hemispheria*, *A. naviformis*, *Leptæna transversalis*, *Pentamerus oblongus*, *P. lyratus*, *P. lens*, *Platyostoma hemispherica*, *Pleurotomaria*, *Murchisonia subulata*, *Orthoceras*, *Beyrichia* and *Calymene Blumenbachii*	10	6
Dark ash-grey limestone, in some parts mixed with yellowish-white, and in such parts of a granular texture; the whole occurring in beds of from one to three inches thick, interstratified with thin beds of greenish shale. The deposit is characterized by an abundance of corals and encrinites; among the corals are *Catenipora escharoides*, *Favosites favosa*, *F. gothlandica*, *F. multipora*, *Zaphrentis*, *Stromatopora concentrica*; and among the other fossils are *Pentamerus oblongus* and *Atrypa reticularis*..............................	10	6
	29	6

It is not improbable that the south coast is occupied by the rocks of Division F, from South-west Point to the vicinity of Chicotte River, a distance altogether of about thirty miles; without further examination, however, it cannot be so stated with certainty; for while there is an interval of seventeen miles beyond the Jumpers, in which only one exposure could be discerned from the boat, there was a farther distance of seven miles in which four exposures were seen, but remained unexamined in consequence of our not being able to land at them from the condition of the surf. A landing however was effected in a cove under two miles west from Chicotte River, and the cliffs which were examined on both sides of the cove exhibited the yellowish-white granular crinoidal limestone of this division.

The rock there formed cliffs, exhibiting about thirty feet of the strata, which appeared to be somewhat disturbed, as the strike and dip were very irregular, the inclination sometimes amounting to so much as twelve degrees.

These beds extend to within about half-a-mile of Chicotte River, and as no instance of them was observed between that and Cormorant Point, and all the exposures met with presented strata resembling those of the immediately subjacent division, it is concluded, as has already been stated, that this stretch of the coast belongs to it.

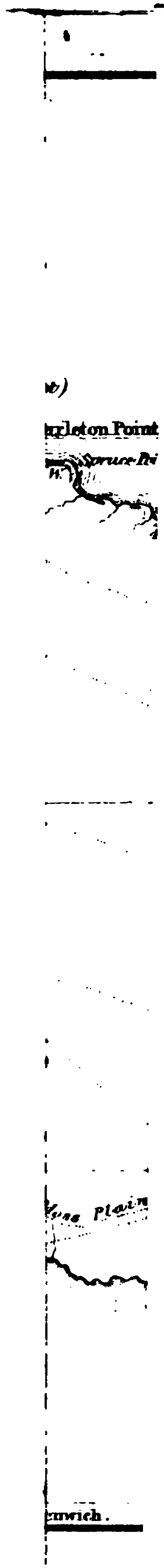
Continuing eastward from Chicotte River, the first ot these exposures occurs at a distance of about two miles and a-quarter, the next commences about seven and a-half miles farther on, being about two miles beyond Pavillion River, where about seven feet of drab-coloured limestone in horizontal strata are seen, with an interval of concealment which continues for a mile, reaching nearly to Martin Brook. The next exposure is on the east side of the cove receiving Iron River, tbe distance from the last being about a mile and a-half. Here about ten feet are displayed in a low cliff, and the strata still horizontal run along the coast for three-quarters of a mile.

Six miles beyond this occurs Chaloupe River, where cliffs are seen at each horn of the bay at its mouth, separated about half-a-mile from one another. The cliffs expose from twelve

to fifteen feet of limestone in horizontal strata which, with an interval of concealment, continue for a mile and a-quarter to the eastward. A mile and a-half further, there is another cliff of horizontal limestone shewing ten feet, and three miles on still another in which twelve feet are seen. These run along the coast for a mile and a-half, and, after an interval at the mouth of a brook, they are repeated in a cliff of from twenty to twenty-five feet and continue for a mile. The next display occurs about five and a-half miles further on, commencing within three-quarters of a mile of the extremity of South Point, and continuing, with an interval at the point, for three-quarters of a mile beyond it. The strata as before, are flat, and they exhibit the following section in ascending order:—

	ft.	in.
Grey limestone in beds of from two to four inches thick, interstratified with grey argillo-calcareous shale; among the fossils are *Atrypa reticularis*, *Leptæna subplana*, *Calymene Blumenbachii* and *Orthoceras*.	6	6
Grey limestone crowded with *Pentamerus oblongus* of large size, to the exclusion apparently of other fossils; nine-tenths of the bed are made up of them, and some of the individuals measured nearly six inches in length..........	0	9
Grey limestone in beds of from one to six inches, with *Orthis flabellulum* and *Calymene Blumenbachii*..........	7	0
Grey limestone holding *Pentamerus oblongus* in abundance, but of small sizes, varying from a-quarter of an inch to an inch and a-half in length; no other fossil was observed..........	0	5
Drab colored limestone in beds of from one to three inches, interstratified with greenish-grey shale, constituting one-fourth of the mass; the shale crumbles under the influence of the weather and yields very perfect fossils; among them are a *Favosites* with small tubes, *F. favosa*, *Zaphrentis bilateralis*, *Atrypa reticularis*, *A. hemispherica*, *Orthis elegantala*, *O. flabellulum*, *Spirifer radiatus*, small individuals of *Pentamerus oblongus*, *Leptæna subplana*, *Calymene Blumenbachii*, *Encrinurus punctatus*, *Orthoceras* and crinoidal columns,..........	14	0
	28	8

A little under half-a-mile beyond this, another cliff of limestone occurs, which runs along the coast for as much more, and probably repeats a part of the section given, the height of the cliff being twenty feet.



rleton Point
Spruce Ri
Plain
nwich.

The strata in the exposures for twenty-four miles up to this point appear to be perfectly horizontal, but the next exhibition on the east side of a small cove, shews a gentle dip to the south-east. The beds form a fifteen-feet cliff of limestone, running for about half-a-mile along the coast, and terminating at the extremity of a point. At the next exposure however, which occurs after an interval of concealment of six miles, they are once more horizontal, and compose a cliff again fifteen feet high, which occupies a mile of the coast; at a mile beyond this the calcareous strata which present themselves shew a dip S. 25 E.$<3^{\circ}$, which after another mile becomes S. 47°E.$<1^{\circ}$; the beds in the last case being superior to those in the preceding one. This dip prevails for about three-quarters of a mile, in which the coast runs oblique to the strata, and then from a dislocation or a twist in the stratification, it very suddenly changes to S. 60° W., which is maintained for about a-quarter of a mile across the measures, along a small cliff occupying that distance. Another concealment of about a mile and a-half brings us to the horizontal limestones which have been already mentioned as existing three miles west of Cormorant Point.

ECONOMIC MATERIALS.

The substances fit for economic application met with on the island are confined to building stones, grindstones, brick-clay, peat, and shell-marl; metalliferous minerals, as far as my observations went, appear to be wanting. The only ore observed appeared to be loose pieces of magnetic oxyd of iron, most probably transported from the Laurentian series on the north shore of the St. Lawrence; there is no reason however for asserting that bog iron ore may not be hereafter found.

Building Stones.—In the immediate neighbourhood of South-west Point, coarse granular limestone for building purposes is displayed in abundance among the strata belonging to Division F. It occurs in beds of from six to eighteen inches in thickness, is easily dressed, and yields good blocks of a yellowish-white color. The lighthouse at the point is built of it, and

so is that at Heath Point, both of which, notwithstanding the coarse and rather open texture of the stone, have stood for upwards of seventeen years I believe, without shewing signs of decay.

The sandstone of Cape James and Table Head would afford a fine material for building purposes; it has a good warm color, being a greenish-grey approaching to drab, rather lighter than the sandstone of Craig Leith quarry, near Edinburgh; it has a free grain, and would therefore dress easily, while the angular fragments on the beach shew that it would retain its sharp edges. Blocks of every required size might be obtained with thicknesses up to five and a-half feet. One solid mass of it which had fallen from Cape James lay on the beach, measuring forty by sixty feet, with a thickness of five feet, and must have contained upwards of 12,000 cubic feet of good workable stone. In the two cliffs which have been mentioned, the bed occupies seven miles of the coast, and its proximity to the sea offers a very easy means of transport to the towns and cities of the St. Lawrence.

Grindstones.—The same sandstone would very probably yield very good grindstones; although slightly calcareous, it is even grained, and there is a sufficient amount of clear sharp grit in it to render it available, while there would be no difficulty in getting any sizes of grindstones that might be required.

Brick Clay.—Clay fit for common red brick exists in some abundance; it was observed of a bluish-grey color, and about ten feet in thickness, half-a-mile up the Otter River, on the south side; and I was informed of its existence up the Becscie River. About five miles of coast in the vicinity of St. Mary's River consists of clay cliffs of from sixty to seventy feet in height, and no doubt much of it might be made available for bricks; some of it however, is of a calcareous character, and contains many pebbles of limestone, fitting it probably for agricultural rather than manufacturing purposes.

Fresh-water Shell-marl.—This material appears to exist in considerable abundance on the island; the bottoms of all the ponds or small lakes that were examined, with the exception of such as were surrounded by peat, were more or less covered

with it. Marl Lake is one of these; it has a superficies of about ninety acres, and although the depth of the deposit was not carefully sounded, its thickness appeared to be considerable. The brook which empties the lake into Indian Cove at the west end, carries down a large quantity of the marl as a sediment to the sea, where it becomes spread out for a considerable space over the rocks of the vicinity.

About three miles west from South-west Point, marl was observed to occupy a position on the bank of a brook, and to extend for a-quarter of a mile inland, presenting a thickness of about a foot covered with peat.

In a lake half-a-mile further inland, it covered the bottom over an area of 200 acres; and on the east side of South Point it was observed reposing on rock close to the shore, covered over by from four to ten feet of peat.

Peat.—Along the low lands of the south coast of the island, from Heath Point to within eight or nine miles of South-west Point, a continuous peat plain extends for upwards of eighty miles, with an average breadth of two miles, giving a superficies of upwards of 160 square miles, with a thickness of peat as observed on the coast of from three to ten feet. On the average this plain may be fifteen feet above high-water mark; and by channels cut through it could be easily drained and faced for working. As far as my knowledge goes, this is the largest peat field in Canada, and the general quality of the material is excellent.

There are many isolated patches also between South-west point and the west end, varying in size from 100 to 1000 acres, which would yield a considerable quantity of the material.

It was stated to me that peat existed also in some abundance in the interior of the island, but this I am disposed to doubt, for while all the streams flowing from the peat plain, on the south side gave as is usual a brown colored water, those in other parts were pure and colourless, leading to the opinion that the interior was peculiarly free from peat swamps.

Among the materials of the island which may be considered of an economic nature though not of a mineral character, seaweed and drift-timber may be enumerated.

Sea-weed.—In all the bays, coves, and sheltered places around the whole island, with the exception of those between the east end and South-west Point, there is a great accumulation of sea-weed along the high-water mark; in such places patches of it are met with of from a hundred yards to half-a mile in length, and from two to six yards in width; the depth usually varied from one to four feet, and in some instances was six feet. The beneficial effect of sea-weed as a manure is too well known to require mentioning, but to what distance it would bear carriage for such an application is more than I am able to state. On the island, Mr. Pope, of South-west Point, makes use of it as a fertiliser for his fields, mixing it with the peat which forms the soil.

Drift Timber.—The quantity of squared timber and saw-logs which are scattered along the south shore of the island, is very surprising; the abundance appears to be greater towards the east end than the west; but according to the calculation which I have made, if the whole of the logs were placed end to end they would form a line equal to the whole length of the island, or 140 miles; this would give about one million of cubic feet. Some of the squared timber may have been derived from wrecks, but the great number of saw-logs, which are not shipped as cargo, induces me to suppose that the main source of this timber is drift.

No doubt the whole of it may have once been private property, and perhaps much of it could be identified as such by private marks; perhaps too no one may have a right to touch it but the owners of the island, to whom it may be a *waif*; but it is to be regretted that it should be allowed to remain on the shore to rot, as much of it has no doubt done. The captain of a fishing schooner that had not been very successful in taking fish, applied to me when I was leaving Heath Point to know where the greatest accumulation of it might be found, expressing an intention of cutting some of the squared timber into convenient lengths and loading his vessel with it for Nova Scotia. More may perhaps be in the habit of pursuing a similar trade.

MINGAN ISLANDS.

From the shortness of my stay at the Mingan Islands, the amount of information collected concerning the rocks which compose them is necessarily limited. It is sufficient, however, to enable me to state that the strata of probably the whole group is in the same horizontal attitude that characterizes those of the Island of Anticosti, and it perhaps is not extravagant to suppose that in the space between the Mingan group and that island the same attitude may be preserved all the way.

The most northern and, therefore, the lowest section I obtained was on the north side of Harbor Island, between which and the rocks of the Laurentian series on the main land there may be a horizontal distance across the measures of about a mile. No measurement was made of the distance, nor was any member of the Laurentian series seen in any place immediately behind Harbor Island, but a mass of Laurentian gneiss or syenite (I was not near enough to decide which) occupied a position on the coast about a mile to the eastward, which would have been in the relation given had the strike of the measures been continued in that direction. Taking this for granted, the section from the gneiss upward would be as follows:—

	ft.	*in.*
Measures concealed	80	0
Yellowish-brown arenaceous limestone in beds of from six inches to two feet thick; a large amount of yellowish-white calc-spar is disseminated in the beds in the form of geodes and of patches, some of which are two or three feet in diameter with a thickness of a couple of inches. Such fossils as exist are generally filled with calc-spar, but they are very obscure	35	0
The following section, taken from the south side of the island, is supposed to succeed the last:—		
Yellowish-grey and yellowish-brown arenaceous limestone with geodes and patches of calc-spar; some of the surfaces of the beds shew corals (?) and fucoids	10	0
Yellowish-grey and yellowish-brown arenaceous limestone as before	8	0
Yellowish-grey and yellowish-brown arenaceous limestone with geodes and patches of calc-spar; *Euomphalus* is abundant but obscure	1	6
Yellowish-grey and yellowish-brown arenaceous limestone, as before, with *Euomphalus*	6	6
Yellowish-grey and yellowish-brown arenaceous limestone, with calc-spar as before, with fucoids but no other observed fossils,	2	4
	143	4

The dip of these measures is about S. 8° W., with an inclination of about eighty feet in a mile. Supposing this were preserved as far south as the range of islands of which Large Island is a member, the distance across the measures from the north part of Harbor Island would be about two miles and a quarter, and the stratigraphical thickness which this would give between the summit of the previous section and the base of the beds of Large Island would be about 117 feet.

The following section obtained on Large Island at its most northern point would then succeed in ascending order:—

	ft.	*in.*
Yellowish-grey limestone weathering yellow	5	8
Green and black shale	2	0
Yellowish-grey limestone with no observed fossils	6	6
Yellowish-grey limestone with *Cythere*	0	9
Yellowish-grey concretionary limestone, weathering yellowish-brown; the concretionary masses are from six to eighteen inches in diameter, and the concentric layers of the concretions are thin	4	0
Dull drab colored limestone, weathering slightly yellow, with nodules of chert; the surfaces of the beds shew fucoids	6	0
Dull drab-coloured compact limestone, weathering slightly yellow, in beds of from six to twelve inches	18	0
Drab-colored mottled arenaceous limestone, weathering yellowish-brown, in beds of from three to nine inches, with corals	10	0
Pale yellowish-grey arenaceous limestone, weathering yellowish-brown in beds of from three to nine inches, well marked with fucoids on the surfaces and impressions of *Euomphalus*	12	6
Measures concealed	56	0
Greenish-drab very compact limestone, resembling lithographic stone in its texture, but injured by the presence of small transparent crystals of calc-spar; the beds are from three inches to one foot thick; this would make a very handsome building stone	5	0
Light-drab compact but brittle limestone, in beds of from six to eight inches, with no observed fossils	20	0
Light-drab compact limestones of the same character	25	0
	171	5

The above beds were ascertained on the west side of the island, but it will be perceived that in the section there are fifty-six feet of concealed measures. In a cove on the east side of the island, beds were observed which are supposed to be equivalent to most of these. They are in ascending order as follows:—

Yellowish-white arenaceous limestone, in beds of from one to two feet thick, without observed fossils; this would make an excellent building stone	8	0
Green calcareo-arenaceous shale	1	6
Light greenish-white coarse grained calcareous sandstone, in ill-defined beds, with numerous obscure fragmentary fossils, and several small black nodules and patches	5	0
Measures concealed	4	0
Green and grey shale	11	0
Drab colored argillaceous limestone in even beds, some of which would probably yield hydraulic lime; on others ripple-mark occurs	7	0
Shale	1	9
Greenish-drab compact limestone, mottled with yellowish-drab organic remains; this would make a handsome marble	10	0
	48	3

The general dip of the whole of these measures on Large Island is about S. 9° W. with an average slope, (there being some slight undulations,) of about seventy feet in a mile; and between the summit of the 171 feet above given, and the next set of beds examined, there would be a thickness of about seventy-eight feet.

The succeeding beds obtained at the south point of the island, near Tower Rock, consist of yellowish-white pure limestone, some parts of which were filled with *Maclurea Logani*, and fragments of trilobites; the thickness of the mass was thirty feet.

The only other place examined was the northern extremity of Mingan Island, which is about four and a-half miles from Mingan Harbour, and forms one of the range of islands comprehending Large Island. The rock was a light grey limestone with thin interstratified beds of green argillaceous shale. The fossils, though abundant, were obscure, and it was difficult to identify any of them.

The Mingan group of Islands appears to possess but little soil. Large Island, although 100 feet above the sea in some places, more particularly on the south and south-west sides, is marked by the levels of ancient sea beaches, composed of small limestone pebbles, and except where the moss has spread over them, but little differences were perceived between the ancient

beaches, and the one at present washed by the ocean. A succession of these beaches is well marked by a series of steps with a horizontal surface above each of an irregular breadth, not always following the sinuosities of the one below, as sometimes two of these steps will run into one. These terraces are elevated above one another from five to twenty or thirty feet.

The south-west portion of the island is a succession of such terraces still nearly devoid of soil. It is only in patches that vegetation occurs, and the patches have a very irregular contour, in no way that I could perceive dependent on the form or direction of the terraces. Sometimes they would shew an irregular outline on a terrace, and then run up or down in an irregular strip to the next terrace, giving to the whole flight of steps a parti-colored aspect, like that of a body partially deprived of its skin.

Another feature which marks strongly the change of relative level in regard to sea and land, and tends at the same time to give much picturesqueness to the scenery is the presence of what have been termed flower-pot rocks. These, as the name imports, resemble flower-pots on a large scale. Hundreds of these stand up out of the rising tide to heights varying from ten to fifteen feet, with breadths from a few feet to thirty or forty, widening toward the top. They are composed of horizontal layers of limestone piled on one another, and are the remains of stratified masses that were once united, but have been gradually worn away by the destructive action of the sea, and while many of those standing in the water to various depths according to the state of the tide, show the waves still at work upon them, some straggling ones are seen away high up in the island, showing a similar action when the relative levels of the sea and land were from fifty to sixty feet different from what they are now.

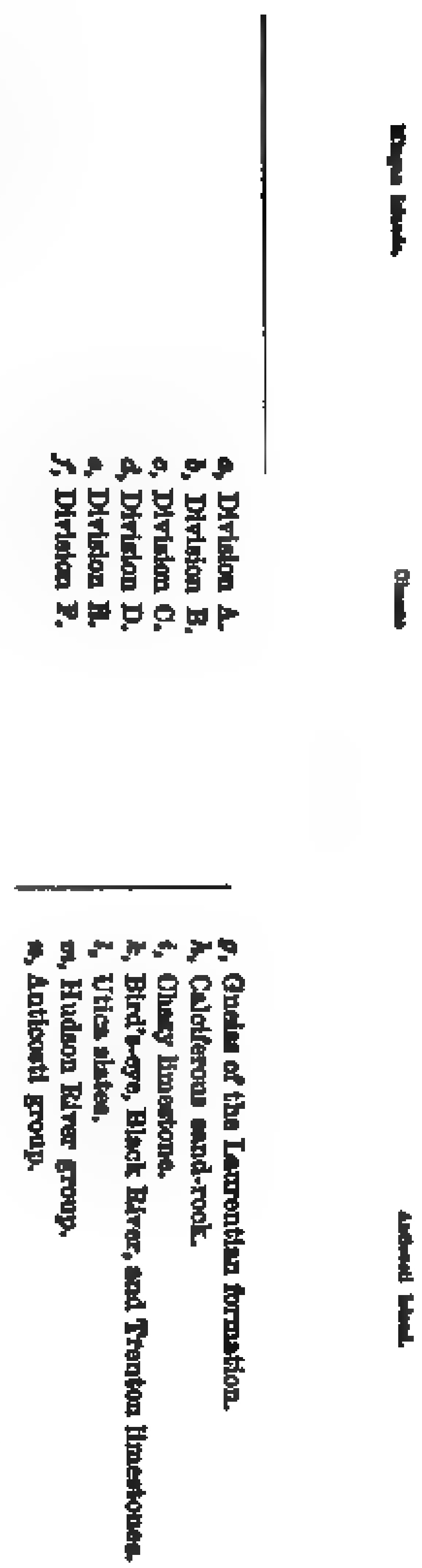
The strike of the Mingan group of rocks does not differ very materially from that of the strata of Anticosti, and the distance across the measures from the highest beds of Large Island to the lowest of Anticosti is about nineteen miles. Supposing that the inclination in this space does not differ from the average of those at the two extremes, which would

not be far from ninety feet in a mile, the thickness of the measures croping out in the water would be about 1,700 feet.

The whole vertical column, from the Laurentian series to the summit of the Anticosti rocks, would then be as follows:—

	ft.	in.
Harbor Island section, supposed to be equivalent in age to the Calciferous sand-rock formation	143	9
Measures concealed by water	117	0
Large Island, north section, supposed to be of the age of the Chazy formation	171	5
Measures not examined on Large Island	78	0
Large Island, south section, supposed to be of the age of the Bird's-eye and Black River formations	30	6
Measures concealed by the water between Large Island and Anticosti, supposed to be of the age of the upper part of the Bird's-eye and Black River formations, the Trenton formation, the Utica slates, and the lower part of the Hudson River group	1700	0
Divisions A., 229 feet, and B., 730 feet, supposed to be equivalent to the upper part of the Hudson River group	959	0
Divisions C., 306 ft. 6 in., and D., 427 ft., showing a passage from the lower to upper Silurian formation	733	6
Divisions E., 540 ft, 9 in., and F., 69 ft, 3 in., supposed to be equivalent to the Clinton group	610	0
	4542	8

The accompanying wood-cut, representing a vertical section from the Mingan Islands across Anticosti, shows the relation of the deposits that have been examined. The vertical is about three times the horizontal scale.



Having in this Report described the geological facts presented to my observation in Anticosti, I am desirous of drawing attention to the inferences that are suggested by the results as connected with the agricultural capabilities of the island. From the facts given in regard to the natural vegetation of the island, or the limited agricultural experiments, of which mention has been made, little of importance can be gathered; but these when taken in combination with the considerations suggested by the attitude and mineral character of the rocks appear to me to merit serious attention.

The strata of Anticosti being nearly horizontal cannot fail to give to the surface of the country a shape in some degree conforming to them. The surface will be nearly a level plain with only such modifications as are derived from the deeper wearing in a longitudinal direction of some of the softer beds, producing escarpments of no great elevation, with gentle slopes from their summits in a direction facing the sun, that will scarcely be perceptible to the eye. The easily disintegrating character of the rocks forming the subsoil can scarcely fail to have permitted a great admixture of their ruins with whatever drift may have been brought to constitute a soil, and it is reasonable to suppose that the mineral character of these argillaceous limestones must have given to those ruins a fertile character. It is precisely on such rocks, in such a condition, and with such an attitude, that the best soils of the western peninsula of Canada West are placed, as well as of the Genesee country in the State of New York. I have seen nothing in the actual soil as it exists to induce me to suppose that in so far as soil is considered, Anticosti will be anything inferior to those regions; and considerations of climate only can induce the opinion that it would in any way be inferior to them in agricultural capabilities.

The three months that I was on the island were altogether too short a time to enable me to form any opinion upon the climate of Anticosti. But taking into view the known fact that large bodies of water are more difficult to cool and more difficult to heat than large surfaces of land, I should be inclined to suppose that Anticosti would not be so cold in

winter nor so hot in summer as districts that are more inland and more south, and that it would not compare unfavorably with any part of the country between it and Quebec. While autumn frosts would take effect later at Anticosti, the spring would probably be a little earlier at Quebec.

But such is the condition of the island at present that not a yard of the soil has been turned up by a permanent settler; and it is the case that about a million of acres of good land, at the very entrance from the ocean to the Province, are left to lie waste, while great expenses are incurred to carry settlers to the most distant parts of the west. Taken in connection with the fisheries, and the improvement of the navigation of the St. Lawrence, it appears to me that the establishment of an agricultural population in the island would not only be a profit to the settlers themselves, but a great advantage to the Province at large.

I have the honor to be,

Sir,

Your most obedient servant,

JAMES RICHARDSON.

REPORT

FOR THE YEAR 1856,

OF

E. BILLINGS, ESQ., PALÆONTOLOGIST,

ADDRESSED TO

SIR WILLIAM E. LOGAN, PROVINCIAL GEOLOGIST.

MONTREAL, 1*st March*, 1857.

SIR,

After joining the Survey on the 1st of August last, I proceeded in accordance with your instructions to make a general examination of the large collection of fossils in the Museum, with a view to their final arrangement for the purpose of public exhibition; this work, with occasional visits to the quarries and exposures of rock in the neighbourhood of the city of Montreal, occupied the months of August and September. In the beginning of October Mr. Richardson arrived from the survey of the island of Anticosti, bringing with him another extensive collection, and shortly after, an opportunity was afforded me of examining these in connection with Professor Hall, the eminent Palæontologist of the State of New York, who was then on a visit to this city.

Since the month of October I have been engaged in determining the species of the fossils, preparing them for the cases, arranging them, and also in drawing up descriptions of the new forms. The characters of such as I have been able to distinguish satisfactorily will be given in the following Report.

In the arrangement of the Museum the first floor has been selected for the exhibition of the economic materials and rock specimens of the older formations, including the altered Silurian. On the second floor will be arranged the fossils of the Lower Silurian; while the third floor will be devoted to the Anticosti group or Middle Silurian, the Upper Silurian, Devonian, Carboniferous, and Drift.

It is proposed for the present to arrange the Lower Silurian fossils in seven groups, following as nearly as practicable the system of the New York geologists. These divisions will consist of:—

1.—THE POTSDAM SANDSTONE.
2.—THE CALCIFEROUS SANDROCK.
3.—THE CHAZY LIMESTONE.
4.—THE BIRDS-EYE AND BLACK RIVER LIMESTONES.
5.—THE TRENTON LIMESTONE.
6.—THE UTICA SLATE.
7.—THE HUDSON RIVER GROUP.

The divisions on the third floor will be as follows:—

1.—THE ANTICOSTI GROUP, consisting of beds of passage from the Lower to the Upper Silurian, and supposed to be synchronous with the Oneida conglomerate, the Medina sandstone, and Clinton group of the New York survey; and with the Caradoc formation of England.
2.—THE UPPER SILURIAN.
3.—THE DEVONIAN.
4.—THE CARBONIFEROUS.
5.—THE DRIFT.

The above classification is intended to be followed in the table cases only, the object being to exhibit in these the palæozoic fauna of the Province uninterrupted by those breaks in the chronological series which do not appear to have extended over all Canada. This could not be effected by introducing and following rigidly the divisions of the New York

geologists, because in the eastern extremity of the province several of their groups can only be ascertained in a general way, their characteristic fossils being so intermingled that with the evidence yet obtained the lines between the formations cannot be drawn with desirable certainty.

In all but the eastern portion, however, the New York system has been recognized, and accordingly, in the upright or wall cases, special collections of the rocks and fossils of each formation, from the Potsdam sandstone upwards, will be placed.

In the table cases the fauna of each division is to be classified in the ascending order, commencing with the Plants in the first case, and proceeding with the Zoophyta, Echinodermata, Brachiopoda, Acephala, Gasteropoda, Cephalopoda, and ending with the Articulata in the last case appropriated to the group. A stratigraphical and zoological arrangement will thus be effected.

In the cases, each specimen is to be mounted on an oblong block of plaster of Paris, bearing a printed label giving the generic and specific name of the fossil, the name of the acknowledged author of the species, the locality where collected, the formation, and the initials of the collector, being an officer of the survey, or the name in full when the collector is not attached to the commission. In making the block the specimen is impressed in it before the plaster becomes hard, it is then removed and the block is afterwards dressed, dried and painted; it is then put in its proper situation in the case, and the fossil placed in the cavity previously formed by itself. The Lower Silurian division is already nearly arranged, and the Upper well advanced.

The classification upon the third floor is founded principally on the new facts brought to light by the survey of Anticosti. Mr. Richardson, as will be seen by his Report, has ascertained that the island consists of a deposit of argillaceous limestone 2300 feet in thickness, regularly stratified in nearly horizontal and perfectly conformable beds. All the facts tend to shew that these strata were accumulated in a quiet sea, in uninterrupted succession during that period in which the upper

part of the Hudson River group, the Oneida conglomerate, the Medina sandstone, and the Clinton group were in the course of being deposited in that part of the palæozoic ocean now constituting the State of New York, and some of the countries adjacent. If this view be correct, then the Anticosti rocks become highly interesting, because they give us in great perfection, a fauna hitherto unknown to the Palæontology of North America. When the great thickness of the rocks between the Hudson River and Clinton groups is considered, it becomes evident that a vast period of time must have passed away during their deposition; and yet as the Oneida conglomerate is unfossiliferous, and the Medina sandstone has yielded but a few inconspicuous species, we have been almost wholly without the means of ascertaining the natural history of the American seas of that epoch. The fossils of the middle portion of the rocks of Anticosti fill this blank exactly, and furnish us with the materials for connecting the Hudson River group with the Clinton, by beds of passage containing some of the characteristic fossils of both formations, associated with many new species which do not occur in either.

These fossils have not yet been thoroughly examined, and consequently in the following lists only those that can be clearly recognized as being of described species will be given. Some of the new forms are characterized in the latter part of this Report, but many others must remain until they can be compared with well authenticated European specimens.

Divisions A and B.

In the lower 960 feet, consisting of Divisions A and B of Mr. Richardson's Report, the fossils that are of known species belong either to the Hudson River group or to the formations below, such as the Trenton limestone. The only exceptions are *Heliolites megastoma*, *Catenipora escharoides*, and *Favosites favosa*, not hitherto considered as Lower Silurian on this continent. They are according to the nomenclature of the Palæntology of New York:—

Chætetes lycoperdon, branched variety,
Heliolites megastoma,
Catenipora escharoides,
Favosites favosa,
Leptæna sericea,
Strophomena planumbona,
——— *alternata*,
Orthis testudinaria,
——— *subquadrata*,
Ambonychia radiata,
Murchisonia gracilis,
Pleurotomaria lenticularis,
——— *umbilicata*,
Conularia Trentonensis,
Calymene Blumenbachii,
Ceraurus pleurexanthemus,

Associated with these are a number of new species, among which are several remarkable cephalopods, such as *Nautilus Hercules*, *Gyroceras* or *Lituites magnificum*, and *Ascoceras Canadense*, to be described hereafter in this Report. About 230 feet above the base, occur the tracks mentioned by Mr. Richardson, which, from all the evidence yet obtained, appear to be confined to a single bed. *Catenipora escharoides* is met with at 430 feet from the base, *Favosites favosa* and *Heliolites megastoma* at 511 feet. A coral, either *Favosites gothlandica* or a closely allied species, is plentiful throughout; and also upwards, through divisions C, D, E, and F. The singular tree-like fossils *(Beatricea)* first occur at Wreck Point, 430 feet from the base, and at numerous localities for more than 1300 feet above. The general aspect of the fossils is that of the Lower Silurian, and as *Ambonychia radiata* is common, associated with great numbers of a beautiful little species of *Cyrtolites*, very like *C. ornatus*, but smaller, it appears very probable that these divisions are a portion of the Hudson River group. At the same time the genera *Catenipora*, *Favosites* and *Ascoceras*, indicate an approach to the Upper Silurian.

Division C.

At Junction Cliff, 950 feet above the base, we find three additional Upper Silurian species, *Leptæna subplana*, *Strophomena depressa*, and *Atrypa naviformis*. The described fossils at this locality and in the next 300 feet, (the thickness of Division C) are:—

Chætetes lycoperdon,
Catenipora escharoides,
Leptæna sericea,
——— *subplana*,
Strophomena alternata,
——— *depressa*,
Orthis lynx,
——— *testudinaria*,
Orthisina Verneuilli,
Atrypa naviformis,
Ambonychia radiata,
Pleurotomaria lenticularis,
Bellerophon bilobatus,
Calymene Blumenbachii.

In this list there are three species, *O. lynx*, *O. Verneuilli*, *B. bilobatus*, (the first and second in great perfection) not yet collected in the two divisions below, although no doubt they occur there. About one third of the new species in the divisions A and B are found in C, the others do not appear any more, and probabably become extinct Of the known species 9 out of 14 occur in the divisions A and B ; the same species of *Favosites* and *Beatricea* are found in great force, and these two alone are almost sufficient to shew that there was no break in the column of organic life at this place. I also think I can recognize here several other Upper Silurian species, such as *Heliolites interstincta*, *Propora tubulata*, and *Leptæna transversalis*. The most striking new form is the species I have called *Pentamerus reversus*, which occurs very abundantly and well preserved in the vicinity of Junction Cliff.

Division D.

In division D the fossils, although numerous, are not so well preserved as in those below; those determined are :—

Chætetes lycoperdon,
Catenipora escharoides,
Stromatopora concentrica,
Leptæna alternata,
——— *subplana,*
Atrypa congesta,
——— *reticularis,*
Murchisonia gracilis,
Calymene Blumenbachii.

There are several other species which occur in Divisions A, B and C, including the *Favosites* and *Beatricea.* At Becscie River Bay, 1265 feet above the base, occurs *Pentamerus Barrandi* of this Report, a species resembling *P. borealis*, but which I am inclined at present to classify as a new form. Many of the beds, through a thickness of 100 feet are packed full of this fossil. At the top of the formation there are several new species of corals, apparently in great abundance.

Division E.

The highest rocks of the last division are 1692 feet above the base of division A., and then succeeds an interval of 27 feet in which no fossils were collected, the measures being concealed. Division E, consisting of 540 feet in thickness of limestone, immediately follows.

There are about sixty species of fossils in Division E., of which the described forms are :—

Chætetes lycoperdon,
Catenipora escharoides,
Favosites favosa,

Zaphrentis bilateralis
Orthis lynx,
——— *elegantula*
——— *flabellulum*
Leptæna subplana,
——— *transversalis,*
——— *profunda,*
Strophomena alternata
——— *depressa,*
Atrypa reticularis,
——— *congesta,*
——— *plicatula,*
——— *hemispherica*
——— *naviformis*
Spirifer radiatus,
Pentamerus oblongus,
Murchisonia subulata,
Cyclonema cancellata,
Platyostoma hemispherica,
Calymene Blumenbachii,
Bumastes Barriensis?

In this list there are twenty-four species, of which all except these four *Favosites favosa, Orthis flabellulum, Leptæna transversalis* and *Platyostoma hemispherica,* belong to the Clinton group. It is probable that many of the other species are also known, at least some of them appear to me to be the same as those figured in various works; but it will require further examination to decide this. For instance, there are two large species of *Pentamerus,* very like *P. lyratus* and *P. lens,* a trilobite scarcely distinguishable from *Encrinurus punctatus,* a *Heliolites* like *H. Murchisoni,* &c.; *Pentamerus oblongus* occupies the upper 150 feet of the division in great abundance; but the two species of the divisions, C and D, *P. reversus,* and *P. Barrandi* have not been seen here at all.

About twenty out of the sixty species are found in the lower divisions, and of these the following twelve are described:—*Chætetes lycoperdon, Catenipora escharoides, Favosites favosa, Orthis*

lynx, *Leptœna subplana*, *Strophomena alternata*, *S. depressa*, *Atrypa reticularis*, *A. naviformis*, *A. congesta*, *Calymene Blumenbachii*, *Murchisonia subulata*..

Atrypa reticularis is not found in the lower divisions A, B and C, but at a locality three miles west of Jupiter River, in beds about 130 feet below the top of division D, it occurs plentifully, and thence passes into E, where it is very abunnant.

Division F.

These are the highest rocks in Anticosti and consist of white limestones crowded with the remains of several large crinoids, but with few species of the other orders of organic remains. They contain *Atrypa reticularis* in abundance, and also numerous fragments of *Bumastes Barriensis*, with some corals, and appear to be a continuation of division E., with a change in the lithological character of the rock. The thickness is about 70 feet.

The divisions C, D, E and F constitute a series of deposits to which it is proposed for the present in the arrangement of the measures to give the name of the Anticosti group. Taking the whole of the Anticosti rocks together, it will be seen by reference to the foregoing lists of fossils that the lower portion is most probably the equivalent of the Hudson's River group, while the upper contains the characteristic species of the Clinton. The middle portion cannot be classified as either Clinton or Hudson River, and yet it contains some species found in the one or the other, or in both. Stratigraphically, it occupies the position of the Oneida conglomerate and Medina sandstones, and is no doubt of the same age. In the Oneida conglomerate no fossils have been found, and of the twenty-one species figured by Professor Hall as occurring in the Medina sandstone, not one has been recognized among those produced at Anticosti. If these several deposits therefore be of the same age, then it follows that in the seas of the State of New York there existed circumstances unfavorable to the existence of marine life, while further east the waters were stocked with an abundant fauna.

NEW SPECIES OF FOSSILS FROM THE SILURIAN ROCKS OF CANADA.

The following descriptions of some of the new species of fossils in the museum of the Survey include several *Cystideæ* published in the Canadian Journal at Toronto, in 1854. It is thought advisable to include them in this Report with the other new forms since discovered, in order to furnish a complete synopsis of all the species of this type of the echinodermata in the collection. I beg that these descriptions may be considered as merely provisional, and that I may soon have an opportunity of republishing them with good figures.

Sub-kingdom, RADIATA; *Class*, ECHINODERMATA; *Order*, CRINOIDEA.

Genus GLYPTOCRINUS.—Hall.

Generic Characters.—Cup pyriform, or sub-globular; pelvis of five hexagonal or pentagonal plates, alternating above which are five primary rays, each supporting upon its third plate two secondary rays, partly included in the general test of the body; four of the spaces between the primary rays hold six interradial plates; the fifth space six or more interradials; above these and between the secondary radials a number of smaller plates; free rays articulated in two series and pinnulated; column round or sub-pentagonal, composed of thin joints with numerous larger and thicker ones at variable distances.

The plates of the species of this genus are flat, thin and either smooth or ornamented with radiating ridges, striæ or raised margins; the large joints of the columns are often nodulose. In the Black River and Trenton limestones in Canada, the remains of several species are exceedingly abundant, but usually reduced to mere fragments of the plates and column. At the city of Ottawa where these rocks are exposed on a large scale, three of the species hereinafter described, *G. priscus*, *G. ramulosus* and *G. marginatus*, appear to be more common than at any other locality yet examined. The heads are

frequently found there in a fragmentary state, but good specimens are rare. *G. priscus* is the only head collected in the Black River limestone, but it also occurs in the Trenton. I have met with *G. lacunosus* near the top of the Trenton limestone only. *G. ornatus* is found about the middle of the deposit, rather common, and in fewer numbers upwards to the Utica slate. There is a sixth species which also occurs at Ottawa, but is only known by its very characteristic sub-pentagonal column.

GLYPTOCRINUS PRISCUS.

Description.—The cup of this species is pretty regularly oval, covered with smooth plates and surmounted by ten long undivided fingers or free rays, which are densely fringed with two rows of pinnulæ. A strong rounded carina or ridge, runs up each of the primary rays, and dividing into two upon the centre of the third plate, sends a branch up each of the secondary rays to the base of the fingers; the carinæ are also divided upon each of the pelvic plates, and coalesce into one on the centres of the first primary radial plates; in the large interradial space a sixth ridge ascends to the top of the cup; dividing the space into two parts about equal, it bifurcates below on the centre of the large interradial, one branch proceeding to the centre of each of the two contiguous first primary radial plates. The pelvic plates are of a moderate size, but the basal plates of the primary rays are large, broad and in contact with each other by their upright lateral margins. The joints of the free rays are very thin and closely set. The rays are also rather broadly rounded on the back. As to the column, the only perfect head in the collection has but a single joint attached to its base, but the columns found associated with it and also those which have been observed in the Trenton limestone at Ottawa, along with the fragments of the heads of individuals of this species, are round with the large joints rather thick and rather nodulose. I think this species grew to a very large size; but the evidence is not sufficient to connect positively the small specimen examined with the large ten-fingered fragments found in the Trenton limestone.

Locality and Formation.—One small perfect head collected at the upper mouth of the cave at the fourth chute of the Bonnechère, in the County of Renfrew, in the Black River limestone. Fragments of the heads and columns apparently referable to this species are common in the Trenton limestone at Ottawa.

GLYPTOCRINUS RAMULOSUS.

Description.—The cup of this species very much resembles that of *G. priscus.* It is covered with smooth plates, and the primary and secondary rays are strongly keeled, but the base is broader, the pelvic plates smaller in proportion to the size of the body, and there are twenty free arms springing from the margin instead of ten, as in *G. priscus.* The arms also are several times bifurcated at various distances from the top of the cup, while those of the former species remain single to their extremities ; the pinnulæ are in two rows, and from one-fourth to three-fourths of an inch in length ; the ossicula of the arms are very thin, and interlock with each other so deeply that each joint seems to extend completely across, giving the appearance of but a single series of joints where in fact there are two. Near the base of the arms there are about two joints in one line, but higher up there are from four to eight in the same length. The arms are regularly rounded on the back, and comparatively slender, being scarcely more than one line in diameter at the base of the largest specimens. In the specimens examined four of the plates of each of the secondary rays are included in the general test of the body. The column is round, and at the base of the cup the large projecting joints are thin, sharp-edged and crowded close together; they gradually become farther apart as the distance from the base of the cup increases, until at length they are from one to three lines removed from each other. Between these large joints the column is composed of very thin plates with crenulated margins, the projecting teeth of one plate fitting into the corresponding notches of those in contact with it above and below. The edges of the large joints are nodulose, and the column is much larger at the base of the cup than at its lower extremity. One specimen tapers from one-fourth of an inch to one-eighth in a length of fifteen inches.

The form of the alimentary canal appears to vary in different parts of the same column, being usually more or less star-shaped, but sometimes circular. The separate large joints are generally seen in the shape of flattened rings, with the outside margin thick and rounded, but thinned down to a sharp edge around the perforation of the centre.

The columns of this species very much resemble those of *Schizocrinus nodosus* (Hall), Pal. of New York, vol. 1, pl. 10, and were always so-called in Canada, until a number of specimens were found with the heads attached. The figures and description of that species however, given by Professor Hall show that it had four plates in the primary rays, and must be therefore not only specifically but generically distinct from *G. ramulosus*. I think that a large proportion of those great columns so common in the Trenton limestone on the Ottawa should be referred to this species and to *G. priscus*. Specimens four or five feet in length are sometimes seen in the quarries, and some of the crushed heads, including the arms, are seven inches in length.

A highly interesting specimen in the cabinet of Dr. Van Cortlandt of the city of Ottawa, consists of the inside of a cup two inches and a-half in length and one inch and seven-eighths in diameter, at the base of the free arms. It had been completely embedded in the stone, but by some means the body has been completely extracted, leaving all the plates lining the cavity in their natural position. The impression of a fragment of the column one inch and a-half in length from the base of the cup downwards still remains. Each of the plates has a small tubercle in its centre on the inside. The characters of the column are precisely those of many of the large ones usually seen without the heads attached. If therefore any of these large columns belong to this species, then in their advanced age they must have lost their nodulose character, because they are smooth instead of nodose, as is the case with the smaller specimens in the collection of the Survey which have the heads attached. It appears to me that in all the species of *Glyptocrinus* the columns were ornamented until past the middle age, and that afterwards they became plain.

Glyptocrinus marginatus.

Description.—The plates of this fine species are all margined by a strong elevated border, the effect of which is to give to the surface a beautifully reticulated appearance. The only specimen in the collection is crushed, but then the size of the plates near the bottom shows that it had a broad rounded base, and that its general form was sub-globular. The large interradial space contains ten plates below the level of the base of the secondary rays; the rays are all carinated, and there is also an upright row of small plates in the centre of the large interradial space which exhibits a faint keel. There are four or five of the secondary radial plates included in the cup. A piece of the column two inches and a-half in length remains attached, and shows that the large joints at the base of the cup of this species were much thicker, and consequently not so sharp edged as those occupying a similar position in the other species.

The length of this cup from the base to the free arms is one inch and a-half, and the breadth about the same. The column is four lines in diameter, and in the length of two inches and a-half there are twenty-one large joints with the same number of others a little smaller, each situated halfway between two of the largest. The arms are not preserved in the specimen.

This species also grew to a large size and was closely related to both *G. priscus* and *G. ramulosus.*

Locality and Formation.—Trenton limestone, City of Ottawa.

Glyptocrinus ornatus.

Description.—In the specimens of this species that have been collected the cup is broad-oval, the base well rounded but narrower than the upper extremity, the rays (as in the other species) are keeled, and there are ten long slender undivided free arms as in *G. priscus.* Each of the plates is ornamented with five or six sharp ridges which radiate from the centre, thus covering the body with numerous stars with triangular

interspaces. The column is round, and the large joints are thin, sharp edged and distant from each other half-a-line at and near the base of the cup in a specimen of the ordinary size.

Length of the cup in several specimens a little more than half an inch; diameter at the base of the free rays about the same; diameter of column at the base of the cup about one line.

The surface ornament of this species is very like that of *G. decadactylus* (Hall) of the *Hudson River group:* but there is a very decided difference in the form of the columns of the two. Those figured by Professor Hall have the large joints very thick and rounded, while in *G. ornatus* they are exceedingly thin and sharp edged; some of our specimens are very like the figure of *G. basalis* (McCoy), given on page 180 of Sir Roderick Murchison's new work Siluria. In Sedgwick and McCoy's British Palæozoic Rocks, page 57 however, that species is described by Professor McCoy as having the pelvic plate immediately below the large interradial space, hexagonal, and supporting upon its upper truncated margin the large interradial. In our species all the pelvic plates are very small and pentagonal; to both the English and New York species ours is evidently closely allied.

Locality and Formation.—Upper half of the Trenton limestone, City of Ottawa.

GLYPTOCRINUS LACUNOSUS.

Description.—This species is characterized by its very large pelvic plates, one of which, that beneath the large interradial space, is hexagonal, and supports upon its upper truncated edge the first interradial. The surface of the body is completely covered with small rugose pits and wrinkles; the rays become free at the second or third secondary radial plate, they divide immediately after becoming free, at least once, perhaps again above, but the specimens do not shew them perfectly above the first subdivision. The body is sub-globular, about three-quarters of an inch in length, and the same in breadth.

The column is round, and when once carefully examined is easily distinguished from that of any other species occurring

in the Trenton limestone. The large joints are proportionally very broad and projecting, while the constrictions between them are wide and deep. At the distance of from six to ten inches from the base of the cup, the large joints disappear altogether, and the column becomes smooth like that of the genus *Thysanocrinus (Rhodocrinus)*; in one specimen at the distance of three inches from the base of the cup, the large joints are nearly one line in thickness at their edges, and are two lines distant from each other; they are also two and a-half lines in diameter; the constricted portion of the column between them is scarcely one line.

Locality and Formation.—Upper part of the Trenton limestone, City of Ottawa.

Genus THYSANOCRINUS (Hall), RHODOCRINUS (Miller).

Generic Characters.—Cup, oval or conical, and of the same structure as *Glyptocrinus*, except that there is a series of five plates (sub-radial) alternating above the pelvic plates, the arms are of medium length, slender, articulated in two series, and fringed with two rows of pinnulæ. The column is also the same as that of *Glyptocrinus* near the base of the cup, but a few inches below becomes smooth and without the large joints; it was attached to the bottom by a branched root-like base.

THYSANOCRINUS (RHODOCRINUS) PYRIFORMIS.

Description.—Cup conical or pyriform, the adult specimens about two inches in length and one inch and a-half in their greatest diameter, which is near the base of the free rays. The pelvic plates are pentagonal, with an obscurely rounded ridge across their base; sub-radials hexagonal, each supporting upon its truncated upper margin a large interradial. The first primary radial on each side of the large interradial space is hexagonal, the other three are pentagonal; the second plates in the rays are hexagonal, and the third heptagonal; each of the latter supporting upon its upper sloping edges the bases of two secondary rays, which become free at the third or fourth plate,

thus furnishing ten arms, which divide at not quite one-fourth of an inch from their base, and again at half-an-inch; the full grown arms are again subdivided, some of them once, others twice. The arms are comparatively short, not exceeding two inches in length in a specimen whose cup measures one inch and a-half in length. The ossicula which constitute the double series of joints of the free rays or arms, are obtusely cuneiform, the two rows interlocking with each other so slightly that the points of the joints extend but a short distance across the centre of the back of the arm; there are two ossicula to one line in length in that portion of the arm at the base which is situated next the cup, and below the first sub-division; the arm here is scarcely one line in thickness. All the plates are smooth or slightly granulated on their surface; in some of the specimens there is a trace of an obscurely elevated margin round the plates, and there is also a broadly rounded keel, not very prominent, upon each of the primary and secondary rays.

The column is round, slender, annulated, with thin but round edged projecting joints, for several inches below the bottom of the cup; it then becomes smooth and continues of an uniform size to the base of attachment, which consists of a number of root-like branches. The annulated portion of the column is usually found a little curved, but the smooth cylindrical portion is always straight, and in this part there are about ten joints to two lines of the length; near the cup there are three or four annulations to two lines. The diameter of the columns is from one and a-half to two lines and a-half, and the length varies greatly; one specimen, a very perfect impression of the head, column and root, all in their natural connection, measured but seventeen inches in length; a fragment of the smooth portion of a column still lying in the rock measures thirty-seven inches and a-half. At Ottawa, in the upper part of the Trenton limestone, there are fragments of smooth round columns, four or five lines in diameter, which appear to be a large variety of this species.

Locality and Formation.—Trenton limestone, City of Ottawa, plentiful; in the upper part of the same formation, around the base of the mountain at Montreal, where the columns are rather common.

Thysanocrinus (Rhodocrinus) microbasalis.

Description.—The specimens for which the above specific name is proposed are about five-eighths of an inch in height, and the same or a little more in breadth at the top. They are cup-shaped, and uniformly expanding from the narrow pelvis upwards. The pelvic plates are so small that they can only be well seen when the column is removed. The rays are keeled, and all the plates of the body exhibit obscure radiating ridges somewhat similar to those of *Glyptocrinus ornatus*, but not so prominent. The column is round, annulated in its upper and smooth in its lower part. I have not seen either the root or the arms.

This species is closely allied to *T. pyriformis*, but differs in its much smaller size, in the comparative minuteness of the pelvic plates, and also in the character of the surface. *T. pyriformis* is a large smooth species, but this one has a surface ornamented with stars, only well seen however on good specimens.

Locality and Formation.—Trenton limestone, City of Ottawa.

Genus Dendrocrinus (Hall).

Generic characters.—In this genus there are five pentagonal pelvic plates, and alternating above these a series of five sub-radials, one of which has its superior angle truncated, and supports a large interradial. There are five rays alternating above the sub-radials; the ray on the left-hand side of the large interradial has two of its plates entering into the composition of the cup; this ray is free, from the third joint inclusive, of the other four rays, only the first joint is included in the cup. A large and long proboscis rises from the interradial plate.

This genus is exactly the same in the composition of the test as *Cyathocrinus* with the exception of the peculiarity that one of the rays has two of its joints contained in the walls of the cup. In the original description given by Professor Hall, (Pal. N. Y., vol. 2, p. 193,) four series of plates are mentioned,

including five " scarcely visible " plates beneath those which I regard as constituting the true pelvis; they cannot be seen in any of the specimens in the collection of the Survey, although at least four of the species are unquestionable congeneric with *D. longidactylus* (Hall).

I have seen Professor Hall's specimens, and he agrees with me that the generic description may be so modified as to receive many species with the same structure in other respects, but which do not exhibit the small plates at the base. It will be seen by refering to fig. 7, c, plate 42, vol. 2. Pal. of New York, that the column of *D. longidactylus* consists of alternately large and small (or thin) joints, and that the latter sometimes consist of five divisions. Professor Hall is now of opinion that the small pieces at first regarded as constituting the true pelvis are not of generic importance, and that they may be considered either as one of the quinquepartate thin plates of the column, or as a basal series so little developed as not to be of more than specific value.

It will be recollected by those who have studied the Crinoidea, that a similar question relating to the base of *Poteriocrinus* still remains unsettled; Professor Philips and the Messrs. Austin having published that genus with three minute plates situated under the three basal plates.

Dendrocrinus gregarius.

Description.—Cup, acutely conical, from three to eight lines in length, and from two to six lines broad at the greatest diameter, which is at the margin, whence to the small pointed base it tapers uniformly with nearly straight sides; pelvic plates, narrow, nearly one-third the height of the cup; subradials, rather more than one-third broader than high; large interradial, not quite so large as the plate on which it stands, broader above than below; proboscis, for several lines above the interradial, nearly as wide as the cup, and composed of numerous small plates, which appear to be regularly arranged in upright rows; the arms bifurcate once immediately after becoming free, and many times again above; they are very

long and obtusely angular on the back. Below the first bifurcation there are about four joints, and they occupy a length of two lines in a specimen where the cup is six lines high and the arms two inches and one-fourth long. Their thickness in this part is about half the width of the first primary radial plates from which they spring, and they appear to hold a very deep groove on their inside, as the thickness is greater in that direction than it is in the other; the column is round, slender and flexible, slightly enlarging near and up to the base of the cup, and composed of alternately thick and thin joints, about six of each in a line of the length; the plates are without ornament.

This species so much resembles *D. longidactylus* (Hall) of the Niagara group that it can scarcely be separated. The principal differences consist in its smaller dimensions, and in the absence of the vertical ridges along the proboscis. On comparing with the illustrations given in the Palæontology of New York, it will be seen that the second plates of the rays on each side of the proboscis are in fig. 1 *a*, plate 43, broader than those upon which they rest. In our specimens the second plate of the left-hand ray is equal to the first; in the right-hand ray it is a great deal less, agreeing in this respect with fig. 7 *a*, plate 42. The species are closely related, and yet I am satisfied they are different.

Locality and Formation.—City of Ottawa, in the central part of the Trenton limestone.

DENDROCRINUS ACUTIDACTYLUS.

Description.—Cup, small, conical, somewhat pentagonal; arms, very slender, several times sub-divided and excessively sharp on the back; column, round, composed of small nearly globular joints; length of cup in the specimen examined, two lines, breadth at base of free rays the same; length of free rays, one inch and one-eighth; thickness upon the back below the first sub-division, about one-fifth of a line. At three-fourths of an inch below the base of the cup there are five joints of the column to one line in length. The two arms visible in the

specimens bifurcate at the fourth free joint, and three times again at varying distances above. Only one side of the specimen can be seen, yet the characters of the cup and arms are so similar to those of the last species that there can be little doubt of its generic affinities, while the globular joints of the column and the thin sharp backed arms are characters sufficient to separate them specifically.

Locality and Formation.—Upper part of the Trenton limestone, near the Toll-gate, St. Lawrence Street, Montreal.

DENDROCRINUS PROBOSCIDIATUS.

Description.—Cup, small, conical sub-pentagonal; proboscis, enormously large in proportion to the size of the cup; column, pentagonal with raised edges along the five angles, and with concave faces between, composed of very thin joints, twenty-four in the length of two lines; the arms are thin and sharp on the back. In a specimen, the crushed cup of which is three lines in length, there is a proboscis attached, sixteen lines in length; the portion seen is of a very remarkable structure; it is composed of four vertical rows of small plates, with a strong central keel running up each row, from either side of which projects, nearly at right angles, a pair of short ridges to the outer side of each plate, giving to the surface the appearance of several small rope ladders side by side, as in the rigging of a ship. This peculiar style of ornament is well shewn in the figures of *D. longidactylus*, (Hall) Pal. N. Y., vol. 2, fig 7 a, plate 42, but the pattern is somewhat different; in that species the transverse ridges diverge from each other at an angle of about 45 degrees, but in this the divergence is only about 20°, producing to the eye a very different effect.

Locality and Formation.—Upper part of the Trenton limestone, near the Toll-gate, St. Lawrence Street, Montreal.

DENDROCRINUS SIMILIS.

Description.—Cup, small, conical and sub-pentagonal; arms, long, three or four times sub-divided, rather broadly rounded

on the back, and comparatively stouter than those of any of the above described species. Of the two arms preserved in the specimen examined, one remains single for a distance of two lines and a-half, and then divides; there are five joints in the undivided part; the other arm shews but two joints in the part below the first bifurcation. The column for seven lines below the pelvis is pentagonal, with round edges and slightly concave faces; it is composed of alternately thick and thin joints, nine of each in the space of two lines, diameter of column nearly one line; length of arms sixteen lines, and the diameter at the undivided part nearly a line on the back.

Locality and Formation.—Trenton limestone, City of Ottawa.

The three last species appear at first sight to be identical, but the moment a magnifying glass is brought to bear upon them, their differences become quite as apparent as those of the large species. In *D. acutidactylus* the arms are exceedingly thin and sharp on the back above the first division like the edge of a knife, and the column is circular and composed of round edged joints, which at the distance of one-half or three-fourths of an inch become nearly globular. In *D. proboscidiatus* the column at the base of the cup is pentagonal with the angles so strongly projecting, and the faces so concave that a single joint has the form of a five-rayed star; the arms, judging from the fragments seen, were very similar to those in *D. acutidactylus*.

In *D. similis* the column is only different from that of *D. proboscidiatus* by the unequal thickness of the joints, and in being more regularly pentagonal; its faces are only slightly concave, its arms also are five times thicker.

DENDROCRINUS CONJUGANS.

Description.—In this species the column about one inch below the pelvis, is round, smooth, and from half to two-thirds of a line in diameter; proceeding upwards it rapidly enlarges to two or three lines, at the base of the cup, which is small, and not much broader at the margin where the arms become free, than it is at the bottom; the pelvic plates are low and broad.

the sub-radials twice as high, and the arm-bearing plates rather more than two thirds the length of these latter; the arms are half the breadth of the plates on which they stand, and broadly rounded on the back; they all divide at the height of about three lines, and again at the same distance above; there are three or four joints in each of the undivided portions. The ray on the left-hand side of the base of the proboscis, which in the generic description is said to have two of its plates included in the cup, in this species has the second plate free, with the exception that it is united on one side to the plates of the proboscis; it is however nearly as broad as the first radial plate upon which it stands, and one-third wider than the first free joint of the arm which rests upon it. This character connects *Dendrocrinus* with *Cyathocrinus*, in which the second joint of the ray in question is entirely free. The column as before mentioned is circular, broad at the base of the cup, and rapidly diminishing in size for a short distance below; it is in this part smooth, but farther down enlarges again, and is composed of thick round-edged compressed spheroidal joints very similar to those of *Heterocrinus simplex*. In one perfect specimen the height of the cup is three lines, the diameter at base two lines and a-half, and at the margin three lines and a-half; length of the arms to first division three lines and a-half, to second division six lines, width of arm to second free joint one line, and of the proboscis the same. In another individual this organ is wider than the arm; in a third specimen the arms divide at the fifth joint, but in every other respect it is the same as this species, although slightly more slender.

Locality and Formation.—Trenton limestone, City of Ottawa.

Dendrocrinus angulatus.

Description.—In this beautiful little crinoid the plates are ornamented with radiating ridges similar to those of *Glyptocrinus decadactylus*. The cup is small, conical and pentagonal; from the centre of each of the rather large sub-radial plates, there proceed six strongly elevated ridges; one to the base of

each of the arms, one to each of the pelvic plates, and one to each of the adjoining sub-radials. The arms are very slender, sharp on the back, and at least twice divided; the three joints of the column which remain attached to the specimen are pentagonal. Length of cup three lines, breadth at the margin four lines, diameter of column nearly one line.

Locality and Formation.—Trenton limestone, City of Ottawa.

Dendrocrinus humilis.

Description.—Cup small, conical; arms, nearly as broad as the first primary radials, divided at the fourth or fifth joints, and again above; the pelvic plates are small, their height about equal to their width, the sub-radials three times larger than the pelvic plates; the first primary radials are low and broad; column, unknown; height of cup, two and a-half lines, breadth at the margin, the same.

Locality and Formation.—Trenton limestone, City of Ottawa.

Dendrocrinus latibrachiatus.

Description.—This species is most closely related to *D. humilis*, the only difference being in the greater breadth and length of the arms, which at the base are quite as wide as the first primary radials, and become a little broader above, whereas in the other species they become narrower from the base upwards. The bottom of the cup is more rounded than in *D. humilis*, and as the columns of both are unknown and as they occur in different formations, they cannot be easily identified at present; the arms are three times divided; length of cup, three lines and a half; of the arms, ten lines.

Locality and Formation.—Hudson River group, Charleton Point, Anticosti.

Dendrocrinus rusticus.

Description.—The base of the cup in this species is broad, like that of *D. conjugans;* the pelvic plates about as high as

they are wide, the sub-radials one-third higher than the pelvic plates; the arm-plates a little shorter than the sub-radials, and broader than high; the interradial is about the size of one of the pelvic plates, and bears three or four small plates upon its summit; the column is round at its junction with the pelvic plates, and composed of thin plates, but one line and a-half below it becomes pentagonal, with raised rounded edges and concave faces; at the distance of two inches below the pelvis there are about three joints of equal thickness to one line in breadth; the arms appear to have been short; breadth of cup, two lines and a-half in one specimen and three lines in another; height of latter to the top of the interradial, four lines and a-half; the whole surface is smooth. The specimens examined are imperfect, but to each there are about three incheg of the column attached.

Locality and Formation.—Trenton limestone, City of Ottawa.

Genus Heterocrinus, (Hall.)

Generic Characters.—The species of this genus are small, and including the arms long and nearly cylindrical crinoids. The pelvis is composed of five small plates, alternating above which are five elongated rays composed of a variable number of joints. They divide immediately on becoming free, and are pinnulated, but as they are nearly always found closed up, specimens in which the pinnulæ can be seen are rare. Hence the genus was originally defined as being without these.

The new species here described have also an interradial plate between two of the rays.

Heterocrinus simplex, (Hall.)

Description.—Sub-cylindrical or elongated fusiform, length including the rays from one to two inches, diameter at half the length from three to four lines. The base of the pelvis in the large specimens is about one line and a-half in diameter, and the body gradually enlarges to about three lines at that point

where the rays divide. The diameter above is always greater, the extent depending upon the amount of expansion of the rays in the particular specimen examined. The pelvic plates are scarcely a line in height, the length of the undivided portions of the rays in the large individuals is about three lines. The ray on the right side of the interradial plates consists of three joints, the first equal in length to the other two, and with one of its angles truncated where it is in contact with the interradial. The ray on the left side of the interradial has four joints, the second being the longest, and having one of its angles truncated to support the interradials.

The other three appear to consist each of four equal joints. The upper joint of each ray is pentagonal, and supports two secondary rays, which continue single to their extremities. The interradial is oblong, higher than wide, five-sided, two of the sides meeting to form an obtusely pointed lower extremity, which rests wedge-like between the truncated angles of the first joint of the ray upon the left, and the second joint of the ray on the right; its upper side is horizontal and supports another plate which is probably the base of a proboscis. The secondary rays, ten in number, consist each of a series of oblong quadrangular joints usually one line in length and two-thirds of a line in breadth.

There is a row of long pinnulæ upon each of the inner margins of each ray, they rise upwards nearly parallel with the rays instead of projecting at nearly right angles as in other species. The column is round and smooth at the base of the pelvis, below which it tapers and becomes very slender at the distance of one or two inches, then slightly larger and composed of compressed globular joints, the rounded edges of which to the eye present a bead-like appearance. The longest column seen with the head attached was fifteen inches, and as it was broken off below, it had been probably several inches longer. The diameter is usually somewhat less than a line, and there are about seven joints of equal size to two lines in length. The smooth slender upper portion of the column near the base of the cup is generally half a-line or a little more in diameter, expanding to twice or three times this size at the pelvis.

Locality and Formation.—Trenton limestone, Ottawa and Montreal.

I had drawn up the description of our Canadian specimens as above, under the impression that they were of a species different from that of the Hudson River Group. But having since seen Professor Hall's collection, I now believe that ours are identical. The original specimen figured in the Palæontology of New York is imperfect, and consequently it was described without noticing the interradial, and also as having a pentagonal column. The species is abundant in the Trenton limestone in Canada, and therefore it is thought advisable to publish the above description, which contains a more full account of its characters. Should, however, it hereafter be found that ours is different from the Hudson River species, I beg that it may be called *H. Canadensis*, the name I had given to it previous to examining Professor Hall's specimens.

Heterocrinus tenuis.

Description.—Much smaller than *H. simplex*; arms long, very slender, and several times divided; column very obscurely pentagonal, composed of sub-globular joints; proboscis extending nearly to the apices of the arms; length, including the arms, from ten to sixteen lines; without the arms, one and a-half to two and a-half lines; diameter at base of arms, about two lines; of column, at base of pelvis, half-a-line.

It is not certain that this species should be referred to the genus *Heterocrinus*. The plates of all the specimens in the collection are so closely united that their number and arrangement cannot be satisfactorily made out. The weight of the evidence is in favor of the genus under which I have placed it. The species, when several times attentively examined, is easily distinguished from *H. simplex*. In that species the column, for a short distance below the cup, is smooth and slender, and it enlarges suddenly from a few lines below, until it forms rather a broad base for the pelvis to stand upon. But in *H. tenuis* the column continues moniliform to the base of the cup and without enlarging, but on the contrary is rather

less in diameter at the point of contact than it is below. In one specimen there are forty-two joints in the first nine lines from the pelvis, and some irregularities in the size can be seen. They are thinner near the cup, and gradually become thicker, so that at two inches from the pelvis there are only sixteen in half-an-inch. The arms, although much more slender than those of *H. simplex*, usually lie folded together, or but slightly separated.

Locality and Formation.—Trenton limestone, Ottawa and Montreal.

Genus HYBOCRINUS, (new genus.)

Generic Characters.—Cup pyriform, or sub-globular, more protuberant upon one side than on the other; pelvic plates five, pentagonal, alternating above which are five large plates, four bearing free arms, and the fifth supporting upon its upper sloping sides two plates, one of which is an interradial, the other an arm-plate supporting the fifth free ray. The columns of the two species known are round and short. The generic name is from the Greek *hubos*, hump-backed.

HYBOCRINUS CONICUS.

Description.—In this species the cup is conical, with slightly ventricose sides; the base narrow, and the arms long and undivided; plates smooth; height of cup thirteen lines from the base of the pelvis on the large side to the upper margin of the interradial; height of the opposite side nine lines; length of the arms three inches; the pelvic plates occupy more than one-half the height on the large side, and about one-half on the others; the arms are one line and a-half in width, and broadly rounded on the back; composed of a single series of joints, each one line in length; on their insides the ambulacral grooves are margined by rows of small plates resembling those upon the arms of some of the Cystidea *(Pleurocystites)*, about five of those plates to one joint of the arm. The column is round and smooth, consisting of very thin joints, ten to one line.

The mode of attachment to the bottom was by a broad button-shaped base. Length of column in the largest specimen seen, one and three-quarter inches.

Locality and Formation.—Trenton limestone, City of Ottawa.

HYBOCRINUS TUMIDUS.

Description. — Smaller than *H. conicus*, sub-globular, the plates tumid in their centres; column, slender and round, composed of thin joints, and tapering towards the base; surface of the plates, obscurely granular; length of cup, six lines; breadth at margin, about eight lines; arms, one line broad upon the back, composed of joints one line in length. Although about twenty heads of this species have been collected, none of them are quite perfect, but they all are smaller and of a different form from *H. conicus*.

Locality and Formation.—Trenton limestone, City of Ottawa.

Genus CARABOCRINUS (new genus).

Generic Characters.—Cup, globular; pelvic plates, five, four of them pentagonal, and the fifth hexagonal; sub-radials, five, four large, hexagonal, and one small and pentagonal. The series of sub-radials is divided on one side by a large interradial, which is supported upon the hexagonal pelvic plate. The arm-plates or first primary radials are also five, and of these, three alternate regularly above four of the sub-radials; the fourth rests partly upon one of the sub-radials and partly upon the large interradial of the second series; the fifth is supported in part by the heptagonal sub-radial, and partly by a plate which stands upon the small pentagonal sub-radial; the fourth and fifth arm-plates are separated by a second interradial, supported by that which stands upon the hexagonal pelvic plates.

Upon the summit five calycinal ambulacral grooves radiate from the centre (where there appears to be an aperture) to the bases of the arms; the mouth is situated in the margin over the interradial plates; there is a small aperture, surrounded by an elevated border half-way between the mouth and the centre.

This genus is distinguished from *Cyathocrinus* and *Poteriocrinus* by the depth to which its interradial plates descend. In the genera cited they are always situated above the sub-radials, but in *Carabocrinus* one of them stands upon one of the pelvic plates. I refer all the specimens to one species. The generic name is from the Greek *karabos*, a crab.

Carabocrinus radiatus.

Description.—Cup, globose, rather broader at the margin than it is high; base, broadly rounded, covered with strong rounded ridges which radiate from the centres of the plates; arms, short, three times divided; column, round and slender, composed of alternately projecting thin joints. From the centre of each sub-radial plate two principal ridges ascend diagonally to the bases of the two arms on both sides; two others radiate to the centres of the two sub-radials on either side, and thus a series of triangles is formed round the upper half of the cup. In a similar manner ridges extend from the centres of the sub-radials to the centres of the pelvic plates, thus constituting another set of triangles in the lower half. Within each triangle, both in the upper and lower halves, are contained two or three smaller triangles, one within the other. In consequence of this arrangement, the ridges appear to radiate in groups of three or four.

Each arm-plate supports in its centre a small but stout pentagonal second radial plate, from the upper sloping edges of which spring two short round arms, which divide again at the second joint; these branches are again divided once or twice above. Height of the largest specimen, one inch; diameter at half the height, fourteen lines. Specimens are in the collection of all sizes, from three lines to twelve in diameter.

Locality and Formation.—Trenton limestone, City of Ottawa.

Genus Cleiocrinus, (new genus.)

Generic Characters.—Cup, large, conical or pyriform; pelvic plates, five; rays, five, alternating with the pelvic plates; the

third plate of each ray is pentagonal and bears two secondary rays, which are several times divided above. Between two of the rays a single vertical series of interradial plates extends from the pelvis to the margin of the cup. The interradials and rays are all firmly anchylosed together by their lateral margins up to the height of the fifth or sixth sub-division. The column is pentagonal in the species known.

This genus has the structure of a *Pentacrinus*, with numerously divided arms all soldered together in the walls of the cup.

CLEIOCRINUS REGIUS.

Description.—Cup, elongate, conical, gradually expanding from the base until near the top, where it is slightly contracted. The margin supports about forty long, very slender, tentaculated free rays. At first sight there appear to be ten small pelvic plates, but upon examination five of these are found to be the first plates of the five rays which rest immediately upon the upper joint of the column; the other five are the true pelvic plates; four of them are pentagonal, and the fifth, which supports the column of interradials, is nearly square; height of each pelvic plate, one line; breadth, the same; the small radial plates which rest on the column between the pelvic plates are a little broader than these latter, but not so high; the column is pentagonal, and the pelvic plates are placed upon the angles of the upper joints, while the bases of the rays are situated upon the straight edges: there are about two joints of the column to one line, and they are alternately thicker and thinner; the column near the lower extremity becomes round and suddenly expands into a broad base of attachment.

The surface of the cup is nearly smooth, only varied by obscure vertical rounded ridges along the centres of the rays and of their sub-divisions.

Length of cup, one inch and three-fourths; breadth near the margin, about one inch; diameter of column, from two to four lines. Nearly all the large pentagonal columns in the Trenton limestone at the City of Ottawa belong to this species.

Locality.—Trenton limestone, Ottawa.

Genus LECANOCRINUS.

Generic Characters.—In this genus there are three pelvic plates, one of them pentagonal and the other two hexagonal; in the second series there are five sub-radial plates, two of which are supported by the two hexagonal pelvic plates, while the other three alternate with these latter. Alternating above the sub-radials are five primary rays of three joints each, and above these, ten secondary rays; some of the species have several small interradial plates in one or more of the divisions between the primary rays.

LECANOCRINUS ELEGANS.

Description.—Cup, small, conical, three lines in height from the base of the pelvis to the upper margin of the first primary radial plate, at which level the breadth is also about three lines; the breadth of the pelvis is one line and a-half, and the top of the column scarcely less; the first primary radials are a little broader than high, and rendered slightly heptagonal by the truncation of their upper lateral angles; the second primary radials are narrower and quadrangular, or obscurely hexagonal; the third are pentagonal; the length of each is about a line and a-half; the third in each of the three rays exposed in the only specimen seen, supports two secondary rays of five joints each, and then divides into two tertiary rays; these latter are again divided; the rays above the fourth division are articulated in two series; between the primary rays are several small interradials. The column is circular, with round-edged joints, from four to six in one line; length of ray from the base of first primary radial to the extremities, one inch and one-fourth.

Locality and Formation.—Trenton limestone, City of Ottawa.

LECANOCRINUS LÆVIS.

Description.—This species is shorter than the preceding, and has only four joints instead of five in the secondary rays; the upper part of the column is round and smooth. In other respects there is much resemblance between the two, but still I think them distinct.

Locality and Formation.—Trenton limestone, City of Ottawa.

Genus POROCRINUS, (new genus.)

Generic Characters.—Cup composed of three series of plates, with one or more small interradials on one side, and with a number of poriferous areas similar to the pectinated rhombs of the Cystidea.

In this genus there are five pelvic plates, five sub-radials, and five first primary radials alternating with each other. as in *Poteriocrinus*, *Cyathocrinus*, and other allied genera. The principal new character upon which the genus is founded consists in the presence of poriferous areas.

Locality and Formation.—Trenton limestone, City of Ottawa.

POROCRINUS CONICUS.

Description.—Cup, one line and a-half in diameter at the base, and gradually enlarging, with slightly ventricose sides, to the width of five lines at the margin; height, seven lines; pelvic plates narrow, nearly two lines high; sub-radials, three lines in height; first primary radials, about two lines and a-half in height and breadth; all the plates smooth; column, circular, smooth, and suddenly enlarged near and up to the base of the cup, composed of very thin joints; free rays, long, slender and single to their extremities; they are about half-a-line in thickness, and appear to be composed of a single series of joints. Only about one inch in length of the column next the base has been seen.

In this species there exists a number of poriferous areas resembling the pectinated rhombs of the Cystidea in their structure, and probably adapted to the performance of the same functions. Their forms and position are however somewhat different from those of any known cystidean. In fossils of the latter order these organs consist of two parts, one situated upon each of two contiguous plates, but in this crinoid, each is so placed that it occupies the angles of three plates. Their form is that of an equilateral spherical triangle, and their size about one line in diameter. There are five situated at the apices of the five pelvic plates, five at the lower angles of the arm-plates, five at the apices of the sub-radials

and five between the arm-plates on the margin of the cup. There are also two or three small ones at the angles of the interradials, in all twenty-two or twenty-three. The pores consist of fine elongated parallel slits, which appear to penetrate through the plates; they are not at right angles to the margin of the plates as in the Cystideæ, but oblique.

The central pore of each division divides the angle into two equal portions, and all the other pores upon the plate are parallel to this central one; consequently in each area they have three directions at which they are at right angles to the sides of the triangular space in which they are situated, but oblique with respect to the margins of the plates.

Locality and Formation.—Trenton limestone, City of Ottawa.

Order CYSTIDEÆ.

Genus GLYPTOCYSTITES.

Generic characters.—Body elongate, cylindrical; test composed of four series of plates, of which there are four in the basal, and five in each of the second, third, fourth and fifth series; three of the basal plates are pentagonal, the fourth hexagonal; ovarian aperture in the only species in which it has been seen, situated in the lower half of the body, without a valvular apparatus; in the summit a small oral orifice from which radiate several calycinal ambulacral grooves which are continued upon the arms; more than three pectinated rhombs; column short and tapering to a point at its lower extremity.

This genus is so closely allied to *Echino-encrinites* that I have had much doubt as to the propriety of retaining it. The principal differences are, that while the European genus has an oval or sub-globular body, and only three pectinated rhombs, *Glyptocystites* has an elongated cylindrical body covered with rhombs, some of them of a large size. The genus was proposed and published by me in the Canadian Journal in 1854, as *G. multiporus*, the only species then known, which, on account of the arms extending down the sides to the base, the great number of the rhombs, and the somewhat irregular arrangement of the plates, appeared to be well separated from *Echino-encrinites*.

Glyptocystites multiporus.

(*G. multipora,—Canadian Journal*, vol. 2, p. 215.)

Description.—One inch in length, five lines in diameter, cylindrical, obscurely five-sided, round at the apex, abruptly truncated at the base; ovarian aperture large, oval; without valves; arms five, four of them extending down the sides to the base, the fifth two or three lines in length; thirteen pectinated rhombs; column short, tapering to a point, composed of alternately wide and narrow joints, the former projecting and striated upon their external edges.

In this species the basal and second series of plates are pretty regular, but the third series contains two plates which are very small in proportion to the others, an irregularity compensated by a corresponding enlargement of two of the plates of the fourth series. The whole of the ... of

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Page 280, line 18. For "second, third, fourth and fifth series," read "second, third and fourth series."

Page 230, line 23. For "Eastward," read "Westward."

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a large one above, which extends from the ovarian aperture nearly to the apex.

On the left side there are two: a small one near the apex, and a large one below but nearly altogether in the upper half of the fossil.

On the anterior side there are four, two at the base, one half of each being on the basal plate of this side, and the other half on the contiguous plate of the second series; a third very small rhomb is situated between the two small plates of the third series, and a fourth very large one divided between the two large plates of the fourth series.

On the right side there are five, a large one next the ovarian aperture, and at its upper angle another which extends across

the side sloping a little downwards, with a third which rises nearly perpendicularly from the anterior angle of the second one; below these there is a half-rhomb, and above the large one first mentioned in this division a very small rhomb only seen in perfect specimens.

In the centre of the apex there is a small aperture, from which a narrow calycinal ambulacral groove extends in each direction towards the anterior and posterior sides for about one line, and then branches into the four arms which continue down to the base; it also sends down a short branch two or three lines into the right side, thus forming the fifth or short arm. These grooves in the perfect specimens are bordered on the apex and for a short distance down the sides, by minute marginal plates which interlock and close the grooves entirely. In the original description given in the Canadian Journal, I described these as constituting a valvular apparatus closing the mouth, but I now think them to be simply the marginal plates of the ambulacral grooves of the arms. On the left side there is situated a minute pore in the centre of a small protuberance near the apex.

The long arms were provided with small slender pinnulæ, six or seven on each side.

Locality and Formation.—This species has been found in the Trenton limestone at Ottawa, Montreal and Beauport.

Glyptocystites logani.

Description.—Length of large specimens one inch and a-fourth; diameter eight lines; cylindrical, obscurely five-sided, abruptly truncated at the summit; base slightly rounded; each plate ornamented with from three to seven exceedingly elevated, somewhat thin, sharp ridges, which radiate from the centre to the sides; spaces between the ridges smooth or very minutely striated; calycinal ambulacral grooves, extending only to the angles of the truncated apex, bordered by marginal plates and furnished near their extremities each with several small free arms or stout pinnulæ articulated in two series; there are about twelve or fifteen conspicuous pectinated rhombs.

The ovarian aperture has not yet been observed; the column is short, strongly annulated and tapering to a point at its lower extremities. It is both pentagonal and circular, and presents a very remarkable character in the fact that the angles of the pentagonal joints form five spiral lines round the column throughout its length. The large joints which constitute the annulations of the column are the circular ones, and those between, the pentagonal.

The detached plates of this magnificent species can be readily distinguished from those of any other crinoid or cystidean of the Trenton limestone by the peculiar star-like appearance produced by the very elevated sharp, and thin radiating ridges with which their surfaces are ornamented. Although a number of the bodies, many of them with the column attached, have been collected, yet none of them show clearly that side in which the ovarian aperture is situated. The plates are more regularly alternating than in *G. multiporus.* This species cannot be identified with the *Echino-encrinites anatinaformis,* figured by Professor Hall on plate 29, vol. 1, Pal. of New York. By referring to that work it will be seen that all the plates of that species are strongly striated with radiating ridges, (see the two figures 4 d and also 4 f,) while in our species they are quite smooth, or only marked with very minute lines; and these, when they can be seen, are in a direction at right angles to that of the striæ upon the New York specimens. Professor Hall's figures do not exhibit any pectinated rhombs, and further, by figure 4 c., it is shown that the base of *E. anatinaformis* is composed of two pentagonal and two quadrangular plates; ours has three pentagonal and one hexagonal basal plate.

Locality and Formation.—Trenton limestone, Island of Montreal; plates in an excellent state of preservation are very abundant in the upper part of the formation. I beg to dedicate this species to the discoverer.

Glyptocystites forbesi.

Description.—The body of this species, judging from the fragments in the collection, is about two inches in length and

three-fourths of an inch in diameter. The character of its surface is such that detached plates may be distinguished at a glance from those of either of the two preceding species, being larger, thicker and more profusely ornamented. When perfect, these plates are somewhat convex, and covered with radiating ridges which are crossed at right angles by coarse striæ. There is usually one strong ridge extending from each side of the plate to the centre, and several shorter ones parallel with these. Those of the latter class which are nearest the larger ridges are the longest, and the others decrease in length in proportion as they are distant from it. From each angle of the plates there is a small sharp ridge extending to the centre. The transverse striæ run parallel with the margins of the plates. The large ridges are sharp edged but broad at their bases. There are usually seven or eight of the transverse striæ to one line; some of the largest plates are eight lines in length, and nearly as much in breadth, showing that the perfect specimens were about two inches long.

One specimen consisting of the column and a part of the basal and second series of plates, shows the remains of the pectinated rhombs at the base of the anterior side, characteristic of this genus. The portions of the rhombs shown by the detached plates indicate that the pores were much shorter in proportion to the size of the plates than in *G. multiporus* and *G. Logani*. The column is annulated, about two inches long, and tapering to a point. This cystidean being from the Chazy limestone, is the most ancient species known on this continent. I beg to dedicate it to the late accomplished naturalist, Professor Edward Forbes.

Locality and Formation.—Chazy limestone, Caughnawaga.

Genus PLEUROCYSTITES.

(*Canadian Journal*, vol. 2, page 250.)

Generic Characters.—Body oval, flat, one side covered with large polygonal plates, the other almost entirely occupied by an enormous opening covered only by an integument of numerous small plates; arms free, two in number, articulated in

two series; one small aperture near the apex, above the large opening, and another at the base near the column.

The following is the arrangement of the plates as described in the Canadian Journal above cited:—"On the upper joint of the column rest four pelvic plates; two of these are pentagonal and spread away from each other in the form of the capital letter Y, and in the angle thus formed is placed the large central hexagonal plate of the second series; the two other pelvic plates are situated one on each side, and partly under the former; they do not unite on the other side and form the cup-shaped pelvis of the ordinary cystideæ, but spread out wing-like from the sides of the column. Each sends out a slender projection at the bottom, which clasps around or rests upon the upper joints. Outside of these again are two other small plates, one upon each wing, making in all six in the basal series." In the second range there are three large plates, one in the centre, hexagonal, with an heptagonal plate on each side. "The third series contains four large plates, elongated vertically; one of these on the right hand of the centre, pentagonal, the other on the left, hexagonal. They are narrowed above to correspond with the decreasing dimensions of the body, which here begins to contract. The other two plates of this row are either heptagonal or slightly octagonal, and at their upper extremities they fold round the body and unite on the other side by narrow projections, which arch over the great oval opening. Above these there are ten smaller plates, which close the summit and form a solid support for the arms.

The column is short and tapers to a point at the lower extremity. There are three pectinated rhombs; one of these is at the base, situated one-half on one of the pelvic plates, and the other half on the large central hexagonal plate of the second series; the other two are situated one on the left pair of plates of the third series, and the other on the right.

The following appear to me to be distinct, but when more becomes known of this extraordinary genus it may be necessary to unite them all into one variable species.

Pleurocystites squamosus.

Description.—In this species the large plates are smooth, and the great opening on the anterior side protected by an integument composed of a vast number of small mostly hexagonal plates, each less than the fiftieth part of an inch in size; the rhombs are small and somewhat elliptical, the larger axes of the two above being transverse to the length of the fossil; column annulated, the edges of the projecting rings striated vertically; in a specimen with a body thirteen lines in length, the left upper rhomb has a major axis of three lines, and a vertical axis of two lines in length. The rhomb on the right is two lines long and one and a-half broad; the basal rhomb about the same size; they are all slightly elevated above the general surface and flat. The pores extend completely across from one side to the other.

Locality and Formation.—Trenton limestone, City of Ottawa.

Pleurocystites filitextus.

(*Canadian Journal*, vol. 2, page 252, 1854.)

Description.—Plates with strong ridges radiating from the centre to the angles, with smaller ones from the centre to the edges; all these are crossed by other striæ parallel to the margin of the plates, which are also in some specimens slightly granular, with small irregular tubercles. The rhombs are large, with straight sides and sharp angles; the greater diagnals extend up and down the fossil instead of across the body, as in the last species. The integument consists of about forty or fifty irregularly polygonal plates. Length of the left superior rhomb in a specimen fourteen lines long, five lines; of the right rhomb three lines.

This species is distinguished from the former by the great size of the rhombs, the striation of the surface, and also by the large plates of the tegumentary covering of the great opening in the ventral aspect.

Locality and Formation.—Trenton limestone, City of Ottawa.

Pleurocystites robustus.

(*Canadian Journal*, vol. 2, page 252, 1854.)

Description.—In this species the rhombs are obscurely elliptical, or rather in the shape of a spherical triangle, one side crossing the suture above, and one of the angles being upon it below; they are surrounded by an elevated border and have a concave surface, instead of being plane as in the two above described species. The plates are ornamented with fine rounded striæ at right angles to the margins, and crossed by a few obscure concentric ridges. The only specimen collected consists of the upper part of the body.

Length of the upper left rhomb, three lines and a-half; breadth in the vertical direction, three lines; the right rhomb is somewhat smaller.

Locality and Formation.—Trenton limestone, Ottawa.

Pleurocystites elegans.

Description.—This species much resembles *P. filitextus*, but may be readily distinguished by the rhombs being shorter, and by the much stronger striation over its whole surface.

Locality and Formation. — Trenton limestone, City of Ottawa.

Pleurocystites exornatus.

Description.—Rhombs, sub-triangular, much elevated above the surface, surrounded by a sharp border; surface profusely ornamented with strong radiating ridges; column beautifully striated longitudinally; the plates of the ventral integument are about the size of those *P. filitextus;* the shape of the rhombs of this species is like that of *P. robustus*, except that the pores form a flat instead of a concave surface.

Locality and Formation.—Lower part of the Trenton limestone, Montreal.

Pleurocystites Anticostensis.

Description.—Rhombs very long and narrow; column with the annulations so coarsely striated that they appear to be nodulose. Only a fragment, consisting of a portion of the column and the lower part of the body of this species, has been collected; in a specimen which measures seven lines from the base of the body to the upper angle of the large hexagonal plate, the length of the right superior rhomb is five lines, and its breadth one line.

Locality and Formation.—Charleton Point, Anticosti, in the Hudson River Group.

Genus Comarocystites.

(*Canadian Journal*, vol. 2, page 227.)

Generic characters.—Ovate, the smaller extremity being the base; pelvis small, of three plates, above which are from eight to eleven irregular rows of plates, mostly hexagonal; ovarian aperture near the summit, closed by a valvular apparatus; arms free, and composed of a single series of joints bearing pinnulæ; column round.

Comarocystites punctatus.

(*Canadian Journal*, vol. 2, page 270.)

Description.—Plates depressed or concave in the centre and covered with small oblong punctuations; ovarian aperture near the summit, closed by five triangular plates; arms four, each composed of a single series of joints bearing pinnulæ; column round, of thin plates. Length of large specimen one inch and a-half, of arms about two inches.

Locality and Formation.—Trenton limestone, City of Ottawa.

Genus Amygdalocystites.

(*Canadian Journal*, vol. 2, page 270.)

Generic characters.—Body ovate or sub-globular; pelvis of three plates, above which are eight or more irregular rows of

plates completing the cup ; ovarian aperture near the summit, closed by a valvular apparatus; arms composed of a double row of joints crossing the summit and articulated to the surface; each joint bears a pinnula ; column round.

Comarocystites differs from this genus by the presence of free arms like those of a crinoid.

AMYGDALOCYSTITES FLOREALIS.

(*Canadian Journal*, vol. 2, page 271.)

Description.—Each of the plates of this species has a low rounded tubercle situated in the centre, from which ridges radiate to the angles; these ridges are scarcely elevated above the surface where they leave the border of the tubercle in the centre, but increase in width and height as they depart from it; they are sharp edged and attain their greatest height at the angles of the plates. The arm crosses the summit and extends nearly to the base upon one side, and only two or three lines from the apex on the other; the ovarian aperture is situated close to the arm on one side of the summit; the column is round. The body is ovate, rounded at the apex, and tapering below to the base; length of body one inch. This species forms a link between *Sphæronites* and *Pseudocrinites*; it has the test composed of a great number of plates like the former genus, and the arms and pinnulæ of the latter.

AMYGDALOCYSTITES RADIATUS.

(*Canadian Journal*, vol. 2, page 271.)

Description.—Plates somewhat convex and ornamented with strong ridges which radiate from the centres to the angles; column round; the body is ovate; ovarian aperture and arms unknown.

Locality and Formation.—Trenton limestone. City of Ottawa.

AMYGDALOCYSTITES TENUISTRIATUS.

(*Canadian Journal*, vol. 2, page 271.)

Description.—Body elongate, ovate; plates smooth in the centre; a low rounded ridge proceeds from the smooth space in

the centre to each of the angles, where it meets the similar ridges, which radiate from the centre of the adjoining plates; between these ridges fine striæ cross the sutures at right angles; the pelvis consists of three broad pentagonal plates; the ovarian aperture is nearly on the top of the summit; length of body 1⅛ inch.

Locality and Formation.—Trenton limestone. City of Ottawa.

Order ASTERIADÆ.

The species of Star-fishes in the collection appear to be referable to the genera proposed by Mr. Salter at the meeting of the British Association, in August last; I have seen no other description of these genera than that given in Silliman's Journal of November, 1856, which is as follows:—

PALÆASTER.—Without disc, avenues deep.
PALÆASTERINA.—Pentagonal, disc moderate.
PALÆOCOMA.—No disc, avenues very shallow.

It is probable that our species, when opportunity can be had for a direct comparison with British specimens, will be found congeneric. The following is the arrangement I propose for the present:—

PALÆASTERINA STELLATA.

Description.—Pentagonal; disc extending half the length of the rays; ambulacral grooves narrow and deep, bordered on each side by a row of small nearly square plates which extends to the ends of the rays; a second row outside of these extends nearly to the end; the remaining space in the angles between the rays outside of the two rows of marginal plates, is filled with numerous smaller plates. Length of rays measured along the ambulacral grooves, three lines; number of marginal plates on each side of groove, sixteen; the rays terminate in a round point and rapidly enlarge, so that at one-half their length their breadth is one and a-half lines; the angles between the rays are broadly rounded.

Locality and Formation.—Trenton limestone, City of Ottawa.

PALÆASTERINA RIGIDUS.

Description.—This species has much the aspect of an *Astropecten;* the diameter is scarcely two inches, the width of the disc being half-an inch, and of the rays at their base about three lines; the grooves are deep and margined by two rows of quadrate somewhat convex plates, the outer row forming a continuous curved margin in the angles between the rays.

In the disc there is a V shaped assemblage of smaller plates between the two marginal rows; there are seven plates to two lines in length of the ambulacral row, and five in the same distance of the outer row at the base of the ray; towards the extremities they become smaller; there are five rays.

Locality and Formation.—Trenton limestone. City of Ottawa.

PALÆASTERINA RUGOSUS.

Description—Two inches in diameter, rays five, acute at their apices and rapidly enlarging to a breadth of four lines at the disc, which is eight lines in width. The specimen shews the upper side of the fossil only; some of the plates are absent from the centre of the disc, but those which remain are very prominent in their centres and roughly ornamented by four or five deep crenulations or furrows from near the centre to the edges, producing a star-like appearance resembling a half-worn plate of *Glyptocrinus decadactylus*; their diameter is from one to two lines.

The rays are composed (at least the backs and sides of them) of four rows of plates which are so very prominent that they appear to be almost globular, and even pointed in their centres, the central rows are the smallest; the first four plates of the outer row occupy three lines in length, and of the inner rows nearly as much. Towards the point of the arm all diminish rapidly in size.

Beneath the outer rows two others can be seen which are probably the outer marginal plates of the under side, corresponding to those of *P. rigidus.*

Locality and Formation.—Hudson River Group. Charleton Point, Anticosti. Collected by J. Richardson.

Palæaster pulchellus.

Description.—Diameter two inches and one-fourth; rays sub-cylindrical, two and a-half lines in width at the base, with a length of one inch; disc three and a-half lines in diameter; grooves narrow, bordered throughout by narrow oblong plates, nine in the length of two lines; the length of these plates in a direction transverse to the rays is about one line; near the disc there appears to be but one row of marginal plates.

Locality and Formation.—Trenton limestone. City of Ottawa.

Palæocoma spinosa.

Description.—About seven lines in diameter; rays five, linear-lanceolate; one line in width at base, flexible, covered with numerous small spines; no disc.

Locality and Formation.—Trenton limestone. Falls of Montmorency.

Palæocoma cylindrica.

Description.—One inch and a-half in diameter; rays five, covered with spines, sub-cylindrical, regularly rounded on the upper side, flattened on the lower, about one line in width at base, and regularly tapering to an acute point.

This species and the preceding appear to be somewhat common; most of the specimens have their rays variously curved, shewing that they were extremely flexible.

Locality and Formation.—Trenton limestone. Ottawa.

Genus Cyclaster.

Generic characters.—Body sessile, circular, discoid, covered with numerous irregularly polygonal plates; mouth large, sub-pentagonal; five ambulacral areas, each composed of two series of oblong plates, and having two rows of large pores which penetrate to the interior.

This genus was discovered about thirty years ago, by Dr. Bigsby, in the Trenton limestone, at the Chaudière Falls, in the vicinity of the present City of Ottawa; the specimen then procured was described and figured without a name, by Mr.

G. B. Sowerby, in the second volume of Zoological Journal, in 1847. Another species was discovered by Mr. Gibbs, of the Geological Survey of England, near Ysptty Evan, in North Wales, in a mass of schistose rocks, in a quarry associated with the Bala limestone; in 1848, Professor E. Forbes described this latter species in the Memoirs of the Geological Survey of Great Britain, in his magnificent paper on the Cystidea. He placed it in Vanuxem's genus, Agelacrinites, with specific name of *Buchianus*.

In 1853, while collecting fossils at Ottawa, I found several specimens of Dr. Bigsby's species, and ascertained that the rays supposed to be grooves for the reception of arms are in fact true ambulacra. This fact I communicated to the Canadian Institute, in 1854, in a paper on the cystideæ, published in the June number of the Journal of the Society of that year. It is scarcely necessary to add that it is not a cystidean, and that in all probability neither *Agelacrintes* of Vanuxem, nor *Hemicystites* of Hall, should be placed in that order. They are low forms of *Asteriadæ*.

CYCLASTER BIGSBYI.

Description.—The body of this species is circular, about one inch and a-half across, and half an inch in height in the centre; It is covered with numerous small plates of various sizes, and except in the ambulacral areas, disposed without order; the mouth, situated in the centre of the upper side, is about two lines in diameter, and apparently five-sided; the other aperture between the rays consist of a space covered with plates much smaller than the average size; these form a small elevation, which is imperfect in all the specimens I have seen, but enough remains to render it almost certain that there was an aperture of some kind in this place.

The ambulacral areas are five in number, radiating from the mouth, precisely like those of a common star-fish, and composed of two series of oblong plates which alternate with each other in the centre of the furrow; there are about ten of these plates to five lines in length, on each side of the ambulacrum.

The pores pass between the plates, one being situated between each two. The ambulacra are three lines wide at the mouth, and about an inch and a-half in length in full grown specimens. As they recede from the centre they curve round towards the right in some specimens, and towards the left in others.

The mouth appears to be composed of ten plates; five of these are at the ends of the ambulacra, and the other five placed in the angles between the ambulacra. In some of the specimens the plates are all smooth, in others covered with small tubercles.

The general aspect of this remarkable fossil is well expressed by Mr. Sowerby, who compares it to a star-fish lying upon an Echinus; it is not quite certain that the animal was permanently attached to the bottom. All that I have collected were seated upon the rock with the mouth upwards, and apparently somewhat flattened by pressure. It is probable that when perfect they were more globular than they are at present; one specimen is detached and shews that the plates covered the whole of the under surface, except a small space in the centre which appears to be without plates; perhaps this was the point of attachment; I see no evidence of a column. As this species has not yet received a name, I beg to propose that of its discoverer, Dr. Bigsby, one of the most able of the first explorers of the geology of this country.

Locality and Formation.—Trenton limestone. City of Ottawa.

Agelacrinites Dicksoni.

Description.—Of this species we have only a fragment, consisting of one perfect ray and two of the interradial spaces; but as I have seen other specimens, I am able to state that the diameter is from three-fourths of an inch to one inch; the rays, are five in number, and constructed upon a plan very different from those of *Cyclaster Bigsbyi*, being bordered by two rows of marginal plates, which rise from the surface and arch over the areas; the upper ends of the plates on one side meet those of the opposite side, in a line over the centre, thus forming for each ray a sort of covered way; the spaces between

the rays are paved with numerous flat sub-imbricating plates. The specimen does not shew the central or any other aperture, it is quite flat, and appears to have been firmly attached. The width of the ray is nearly two lines at its origin, and it tapers gradually to a point at the distance of five lines.

Like those of *C. Bigsbyi*, the rays of this species are curved; there are five marginal plates in two lines, and their height is nearly one line; I beg to dedicate this remarkable species to Andrew Dickson, Esq., of Kingston, C. W., one of the best workers in the field of Canadian geology,

Sub-kingdom, MOLLUSCA; *Order*, BRACHIOPODA.

Genus PENTAMERUS (Sowerby).

PENTAMERUS REVERSUS.

Description.—Orbicular, transversely elliptical; dorsal valve the larger, exceedingly convex, with an elevated, broadly-rounded, very tumid umbo; beak small, incurved within that of the ventral valve; broad, slightly elevated mesial fold occupied by four or five rounded or obtusely angular ridges, which disappear at about two-thirds of the length from the base to the top of the umbo; four or five similar short ridges on each side. Ventral valve, shorter, and only one-half or one-third the depth of the dorsal valve; a broad, shallow, mesial depression extends two-thirds the length, and is continued below under the base or front, so as to produce a deep oblong sinus in the margin of the dorsal valve; three or four obscure folds in the mesial sinus, and four or five short ones on each side, the number being variable on both valves. The small acute beak is without an umbo, and is not at all incurved, but rather slopes outward, exhibiting what appears to be a small cardinal area on each side.

Width of full-grown specimen, thirteen lines; height, eleven lines; depth, nine lines. The umbo of the dorsal valve is nearly a line higher than the beak of the ventral. The young specimens are much flatter than the full grown ones, the valves nearly equal, and the surface nearly smooth.

This species is somewhat like *P. Sieberi* (v. Buch), but is distinguished easily by the reversal of the valves, the dorsal being the larger.

Locality and Formation.—Middle Silurian. Junction Cliff, Anticosti.

Collector.—J. Richardson.

PENTAMERUS BARRANDI.

Description.—Elongate, oval, narrowed above, rounded below; dorsal valve, the shorter, depressed convex, most projecting at one-sixth the length from the beak, which is strongly incurved under that of the ventral valve; a barely perceptible mesial sinus; in the lower one-third, some very obscure flattened radiating ridges; ventral valve very convex, with a high and very conspicuous umbo, beak incurved down to the umbo of of the dorsal valve; a slight mesial fold which continues all the way to the beak, and is bordered on each side in its passage over the umbo by an obscure shallow furrow; about sixteen scarcely visible broad rounded radiating ridges. Length one inch and three-quarters, width one inch and a-quarter, depth one inch; the width is variable.

Locality and Formation.—Middle Silurian. Becscie River Bay in vast abundance.

Collector.—J. Richardson.

Genus ORTHIS, (Dalman.)

ORTHIS GIBBOSA.

Description.—About the size and shape of *Orthis testudinaria*, but with both valves convex; greatest width at the centre or a little in front of the centre of the length; above which the sides are somewhat straight and converging to the extremities of the hinge line, the latter about one-sixth shorter than the greatest width; the front margin very broadly rounded; almost straight or even slightly sinuated in some specimens, for one-third of the width in the centre; front angles well rounded; the ventral valve is depressed, pyramidal, most elevated at

about one line from the beak, which is small, pointed, and but slightly incurved; a broad, shallow, mesial depression occupies the front of this valve, but disappears usually at one-half the distance to the beak; cardinal area triangular at the base, nearly at right angles to the plane of the margin, but curved over above, owing to the backward projection of the beak. Dorsal valve exceedingly convex in most specimens; greatest elevation about the centre, often a barely perceptible broad mesial elevation towards the front; cardinal area small, lying in the plane of the margin; beak very small and scarcely projecting from the upper edge of the area; the whole surface is covered with fine striæ which are about twice sub-divided; the cast of the interior of the ventral valve shews that the muscular impressions were bordered by strong lamellæ extending downward, slightly converging at three lines from the beak; in a specimen eight lines wide they were separated by a median ridge with a broad base and sharp edge; width of large specimen eight lines; length six lines and a-half.

Locality and Formation.—Black River limestone. La Petite Chaudière Rapids, Ottawa River.

Collector.—E. B.

ORTHIS LAURENTINA.

Description.—Semi-elliptical, broader than long, in the proportion of about seven to five; hinge line straight, slightly exceeding the width of the shell; the dorsal valve nearly flat, very slightly convex, the most elevated point being at the minute beak, a perceptible depression along the centre; cardinal area low, triangular, inclining forward at an angle of 100° or a little more; foramen partly closed above. Ventral valve convex, most elevated at one-third from the beak, which is small, pointed and slightly incurved; cardinal area large, triangular, somewhat concave, owing to the incurvation of the beak; foramen narrow, extending to the beak, but closed by a convex semi-cylindrical deltidium, except a small triangular space at the hinge line; the surface covered with about twenty-three thick, sub-angular, prominent, radiating ridges which gradually

enlarge from the beak to the base, separated by the same number of sulci equal to the ridges in breadth and depth. Some of the specimens are obscurely sub-quadrangular. Breadth of large specimen seven lines; length five lines; resembles *Orthis tricenaria*, but is smaller and has not the open foramen of that species.

Locality and Formation.—Middle Silurian. Junction Cliff, Anticosti.

Collector.—J. Richardson.

Order GASTEROPODA.

Genus MURCHISONIA, (d'Arch. & de Vern.)

MURCHISONIA GIGANTEA.

Description.—Very elongate, acutely conical; whorls about ten, ventricose, and with indications on the cast of an obtuse angulation or spiral band. Apical angle 20°; length nine inches; breadth of last whorl, which however is proportionally broader than the others, two inches and a-half. Some of the fragments shew the obtuse rounded angulation in the centre of the whorl very distinctly, and also a very shallow concave spiral band above and another below. These latter appearances are however barely perceptible, and may not exist in perfect specimens.

Locality and Formation.—Middle Silurian. Prinsta Bay, Anticosti.

Collector.—J. Richardson.

MURCHISONIA TERETIFORMIS.

Description.—Elongate, conical; whorls about ten, ventricose, regularly convex, apical angle 27°, length six inches.

This species differs from the *M. gigantea* in being more obtusely conical, and in the absence of the angulation on the whorls.

Locality and Formation.—Lower Silurian. Charleton Point, Anticosti.

Collector.—J. Richardson.

Murchisonia rugosa.

Description.—Very elongate, subulate; apical angle 15°, whorls ten or twelve, regularly convex; surface marked with coarse striæ which cross the whorls with a broad rounded undulation backwards, most pronounced in the upper two-thirds of the whorls; length seven inches. This species tapers more gradually than either of the preceding. There are some traces of numerous rounded ridges ascending the whorls spirally, and also of an angulation beneath the suture. Of the surface markings only a few are preserved on a single specimen, upon two of the whorls near the aperture.

Locality and Formation.—Lower Silurian. English Head, Anticosti.

Collector.—J. Richardson.

Murchisonia multivolvis.

Description.—Elongate, acutely conical, apical angle 17°, whorls twelve to fifteen, ventricose in their lower one-third only, above which they taper with a flat or slightly concave surface to the suture, close to which there is an angulation. The striæ, after leaving the suture above, turn back at an angle of 45°, and cross the flat upper two-thirds of the whorls in a straight line, or with a very slight sigmoid curvature until they at length sweep with a short rounded curve over the lower projecting part of the whorl, when they turn forward to the suture below. Length, three inches; breadth of last whorl eleven lines.

Locality and Formation.—Lower Silurian. South-west of West-end light-house, Anticosti.

Collector.—J. Richardson.

Murchisonia modesta.

Description.—Conical, apical angle about 50°; whorls, five, with a rounded angular carina on the cast of the interior, situated a little above the centre, a second inconspicuous keel

close to the suture, between which and the outer central carina, the whorl is slightly concave; below the centre of the whorl there is at first a barely perceptible concave band, one line and a-half wide. Length from eight lines to one inch, two lines; breadth of last whorl in one specimen, one inch ; length, nine lines.

M. bicincta (Hall), has an apical angle of 57°, and the upper carina distant from the suture. The proportions of this fossil, and the above description are very near those of *M. cancellatula* (McCoy, British Palæozoic fossils, page 244); but there the upper carina is more prominent than in this species, and the whorls more convex on the outside and below. There are other specimens with the whorls more angular, from the same locality (English Head), associated with these, which for the present I have referred to *M. cancellatula.*

There are others from Pauquette's rapids closely resembling these; but the perfect shell shows a slightly prominent carina about half-way between the suture and the outer margin, which is visible on the cast, while in this species in the same place there is a perceptible concavity.

Locality and Formation.—Lower Silurian. English Head, Anticosti.

Collector.—J. Richardson.

Murchisonia varians.

Description.—Obtusely conical ; apical angle about 58° ; volutions five; a broad band on the outer margin of the body-whorl with three obtuse carinæ; the upper one strongest, the central somewhat less, and the lower the least; a fourth carina at the suture, between which and the upper marginal one the whorl is concave; the upper whorls show but one rounded keel in the centre, the lower two of the body-whorl having disappeared or become obsolete. Length six lines, of which the body-whorl occupies one-half nearly. Breadth at base, five lines and a-half.

Locality and Formation.—Lower Silurian. English Head, Anticosti.

Collector.—J. Richardson.

Murchisonia turricula.

Description.—Small, conical; apical angle about 42°; whorls three or four, a very thick and projecting carina about the centre of the whorls; below, a broad flat keel, rounded on its lower side by a much smaller sharp carina; another on the upper part of the whorl, close to the suture, of a square step-like form, strongly marked with rather coarse striæ which curve sharply backward and then descend the vertical side with a curve forward; umbilicus apparently small; length five and a-half lines; breadth at aperture five lines. This species is remarkable for the prominence of the central carina, and the nearly rectangular strongly striated band at the suture. The specimens examined are imperfect.

Locality and Formation.—Middle Silurian. The Jumpers, Anticosti.

Collector.—J. Richardson.

Murchisonia papillosa.

Description.—Obliquely conical; apical angle about 75°; whorls four; a broad concave vertical band truncating the outside, upon the upper angle of which is the narrow spiral band proceeding from the slit in the aperture. Lower side of the body-whorl, ventricose; upper side scarcely concave, until near the suture, which is followed by a spiral sub-muricated band of short radiating ridges; whole surface covered with small tuberculous points, about the tenth of a line in diameter; these are arranged in rows which seem to mark out the direction of the striæ; in ascending from the place of the umbilicus, their course is nearly vertical until they reach the lower carina; in crossing the broad spiral band they curve very slightly forward, in the narrow band backward, and thence on the upper surface of the whorl, forward to the suture; both of the spiral bands are bordered by sharp keels, of which there are three, one on the upper side of the narrow band, one on the lower edge of the broad band, and one which separates the two. There is no umbilicus, it being concealed by the folding ones

of the inner lip. Length of most perfect specimens, nine lines; width of base seven lines and a-half; of the larger band at the aperture, one line and a-half; of the small band, one-third of a line; depth of respiratory slit, one line and a-half; closely related to *P. Baltica, Murch*, and *de Vern.* Geol. Russia, Plate 23.

Locality and Formation.—Middle Silurian, one mile east of Junction Cliff, Anticosti.

Collector.—J. Richardson.

PLEUROTOMARIA SUPRACINGULATA.

Description.—Obtusely conical or lenticular; apical angle, 105°; height about two-thirds the width; whorls four, angulated and keeled on their upper outer margin, their sides vertical, their upper surfaces gently convex from the distinct suture half-way to the margin, and then scarcely concave to the spiral band; lower side of the body-whorl convex; the spiral band narrow, and lying wholly on the upper side of the whorl, where it forms a border along the margin following all the whorls to the apex; umbilicus large; width one inch and a-quarter; height ten lines; width of umbilicus at centre of body-whorl three lines and a-half; width of band on last whorl about half-a line.

The most striking character is the position of the band upon the upper surface of the whorls. In *P. rotuloides* (Hall), it is about the same size, but forms a narrow vertical truncation of the edge of the whorl, while in this species it lies in the plane of the upper surface. The cast somewhat resembles *P. lenticularis*, Hall, but differs in having an obtusely rounded margin, and in the whorls being distinctly truncated one above the other. The specimen examined retains a large portion of the shell, and yet the striæ are not sufficiently distinct to be noticed.

Locality and Formation.—Trenton limestone. East side of St. Joseph's Island, Lake Huron.

Collector.—A. Murray.

Pleuratomaria thalia.

Description.—Small, obtusely conical, oblique; apical angle 74°; whorls three; body-whorl with a sharp keel close to the suture, another half-way to the outer upper margin, where there is a third which is perceptibly stronger than the others; below this is the marginal band, bordered on its under side by a fourth sharp keel; three others equally sharp and prominent follow between the fourth and the umbilicus, and it is probable that as the shell became larger, still others were developed below; of these seven keels, the first, sixth and seventh are concealed within the spire after the first turn from the aperture; the second and fifth are lost in the next whorl; the striæ are fine but well exhibited, their course is nearly directly across the whorl, but with slight curvature backwards, commencing from the suture, and most extended on the outer margin; length four lines, breadth about four, width of marginal band half-a line, of the first band rather more than half a line; those on the under side of the whorl are a little nearer together than those above. All the bands are concave, and the different keels are prominent; the umbilicus appears to be small.

The surface markings of this little shell are very similar to those of *Euomphalus funatus*, as figured and described by authors. In the only specimen examined the aperture is imperfect, and the umbilicus filled with limestone. The surface is well preserved on two of the whorls, and in none of the spiral bands do the striæ make the sharp backward curve which marks the band proceeding from the slit in the lip of *Murchisonia* or *Pleurotomaria.* On the contrary they are so uniformly direct in all the furrows that no particular one can be singled out by the character of its striæ as the respiratory band.

Locality and Formation.—Middle Silurian, one mile east of Junction Cliff, Anticosti.

Collector.—J. Richardson.

Pleurotomaria circe.

Description.—Obtusely conical; apical angle 72°; whorls four; upper surface slightly convex near the suture, and con-

cave towards the margin, which in the cast presents a prominent somewhat sharply rounded angle; lower side slightly convex; a barely perceptible concavity just below the angle inclining inward; lower or exterior side of body-whorl very ventricose; umbilicus small; height one inch; width of base at the aperture ten lines; the body-whorl which is large, occupies one-half the length. The specimen is a cast, and does not show the surface markings.

Locality and Formation.—Lower Silurian. English Head, Anticosti.

Collector.—J. Richardson.

Genus CYCLONEMA, (Hall.)

CYCLONEMA PERCINGULATA.

Compare *C. sulcata*, (Hall) Pal. N. Y., Vol. 2, page 348.

Description.—Obtusely conical; apical angle about 83°.; whorls three, ventricose, most acutely rounded and projecting at about one-third their height; surface with numerous conspicuous ridges, following the whorls spirally from the aperture to the apex, seven in three lines on the lower part of the body-whorl, more distant above; separated by shallow concave spaces in which are sometimes seen intermediate smaller parallel ridges; usually but one of the smaller half-way between each two of the larger; the latter when examined with a magnifier, shew a rather sharp edge imbricating towards the apex like the crest of a wave; whorls crossed by broad obscure rounded undulations or ridges from one to two lines apart, which incline backwards from the suture, at an angle of about 45° with the longitudinal axis of the shell; whole surface also cancellated with fine barely visible striæ, one set of which is in the direction of the large spiral striæ, and the other transverse, following the curves of the undulations. Height, one inch; breadth, ten lines; perhaps identical with *C. sulcata* above mentioned, but appears to be larger and proportionally more depressed.

Locality and Formation.—Upper Silurian, South-west Point, Anticosti. Niagara and Clinton Groups.

Collector.—J. Richardson.

There is a variety with the apical angle a little more obtuse, having all above the body-whorl trochiform, and the spire acutely pointed. In the specimens upon which the species is founded the whorls are all ventricose, somewhat depressed on the upper side, and the suture distinct, but in the variety they are flattened above, and the suture not so deeply distinguished in the plane sloping sides. In any other respect however there is no difference between the specimens sufficient to separate the species.

CYCLONEMA VARIANS.

Description.—Ovate, sub-spherical; whorls three, oblique, rapidly enlarging from the apex; body-whorl very large, the two above small and somewhat depressed, all of them ventricose; somewhat obscurely exhibiting a broadly rounded angle along the centre; often regularly rounded; suture canaliculated; apical angle about 100°; surface reticulated by very fine flexuous transverse and longitudinal striæ, the latter being usually the more distinct, the former sometimes absent or obsolete. On many specimens the body-whorl near the aperture is crossed by rough imbricating lines of growth which are often undulated backwards about the centre, like those of a *Murchisonia* or *Pleurotomaria;* umbilicus small; height of a large specimen thirteen lines, breadth twelve lines. The forms above indicated might be regarded as constituting two species; a large number, however, of very good specimens of all sizes, which were procured from the same mass of rock in Anticosti, show that the differences gradually fade in a series, so that no line of demarcation can be drawn. Although from the character of the striation in some instances, a slit or notch in the margin of the lip might be expected, yet none appears in specimens which are certainly perfect. The species is much larger and more ventricose on the body-whorl than *C. cancellata* (Hall), more depressed than *C. ventricosa*, and more elevated than *Platyostoma Niagarensis.*

Locality and Formation.—Middle Silurian, South-west Point, ticosti.

Collector.—J. Richardson.

SUBULITES RICHARDSONI.

Description.—Elongate cylindrical, fusiform, acutely pointed; length five inches; diameter at the posterior part of aperture one inch and a-quarter; whorls five, flat; suture obsolete; aperture very long and narrow.

This species has much the aspect of *Subulites elongata,* (Emmons) but is proportionally one-half thicker, and is upon the whole a larger species. Perhaps these fossils should be added to the genus *Macrocheilus* (Philips).

Locality and Formation.—Lower Silurian, Charleton Point. I beg to dedicate this species to Mr. James Richardson, of the Geological Survey of Canada, a most indefatigable and successful explorer and collector.

Class CEPHALAPODA, (Cuvier.)

Order TETRABRANCHIATA, (Owen.)

Genus NAUTILUS, (Gualtieri.)

NAUTILUS HERCULES.

Description.—Sub-orbicular, whorls about two, umbilicus wide, shewing the spire; section of shell transversely elliptical or sub-triangular; diameters as four to six; dorsal aspect broad and but very moderately convex, sides rounded, most prominent on the outer edge, thence descending with a convex slope into the umbilicus; septa simple, two to one inch of the dorsal circumference near the external chamber, more approximate near the apex ; siphuncle ?

This fine large species may be readily recognised by the great breadth and comparative flatness or gentle convexity of the dorsal side. The specimen examined is six inches and a-half in diameter, measured from the mouth across to the opposite side. The width of the aperture is four inches and four lines; the depth of the chamber of habitation is five inches on the outside, and about two and a-half on the inside next to the penultimate whorl of the spire; the shell tapers at the rate of about one line and a-half to the inch.

In the only specimen collected the cavities of the unbilicus and also that of the aperture, are still partially filled with the matrix, and all the characters cannot therefore be ascertained.

Locality and Formation.—Lower Silurian, Charleton Point, Anticosti.

Collector.—J. Richardson.

Genus GYROCERAS, (Meyer.)

GYROCERAS (LITUITES) MAGNIFICUM.

Description.—Shell extremely elongated; discoidal spire about eight inches in diameter, the produced free extremity at least twenty inches in length in the full-grown individuals; whorls about three, scarcely contiguous, more nearly so in some specimens than in others; section of the tube semi-elliptical towards the aperture, and semi-circular near the apex; dorsal aspect or outside of the shell nearly flat, while the inside is convex; septa distant about five lines, measured on the centre of the dorsal aspect, in crossing which they make a deep undulation towards the apex; siphuncle situated a little to the right and below the centre of the tube, one line in diameter in its passage through the septum, dilated in the chambers so as to constitute elongate oval expansions two lines and a-half in diameter.

The specimens of this extraordinary fossil are in a bad state of preservation, and it cannot thus be shewn that they possess all the generic characters of *Gyroceras.* The genus as defined by Barrande, Koninck and others, consists of shells spirally inrolled in the same plane at their smaller extremities, the whorls not being in contact, while the large open end of the tube, after leaving the spire, is produced to a greater or less distance and more or less curved. The section, according to Koninck is either oval or angular; M. Barrande has ascertained that the mouth is "neither round nor elliptical, as in other allied forms, but half closed by a bending back of the shell on itself." (Quarterly Journal of the Geological Society, vol. 10, Translations and Notices, page 23.) The mouth has not been seen in

the species above described, and the whorls, although separate, are so much approximated to each other, that should it hereafter be discovered that the mouth has not the form peculiar to *Gyroceras*, it may be necessary to classify the species as a *Lituites*.

In one specimen the breadth of the flat dorsal side is two inches and four lines, in another the length of the free portion of the shell is twenty-one inches, and it is yet imperfect; the diameter of the spire of a third specimen is six inches, and of a fourth eight inches; the produced portion is not straight but gently curved in the same direction and plane as the spire.

Locality and Formation.—Lower Silurian, near the South-west end Lighthouse, Anticosti.

Collector.—J. Richardson.

Gyroceras (Lituites) vagrans.

Description.—Shell elongated, tapering at the rate of nearly two lines to the inch; laterally compressed, section elliptical, dorso-ventral diameter greater than the lateral, apparently in the proportion of twelve to eight; about seven inches of the apical extremity of the shell spirally inrolled so as to form two whorls not in contact, the interior one of which is one inch in diameter, and the exterior three inches; septa convex, distant one line and a-half at a dorso-ventral diameter of one inch.

The specimen exhibits an artificial polished section passing through the central plane of the whorls, shewing clearly the construction of the tube to the apex, where it has a diameter of only one line; some of the septa and almost one-half of the transverse section, but neither the siphuncle, the character of the surface, nor the length of the produced oral extremity is indicated; several specimens still lying imbedded in the rock which are known to me, are in my opinion of this species, and if so, then the free portion was gently curved, and in some individuals at least six inches in length, thus giving thirteen inches as the total length. It is scarcely necessary to observe that from the above materials the generic rank of the fragment cannot be determined with the certainty desirable; the tube is

too much curved to come within the definition of *Cyrtoceras*, the whorls too widely separated for *Nautilus* or *Lituites*, and yet, without a view of the aperture we cannot say positively that it is a *Gyroceras*.

Formation.—Black River limestone.

Localities.—La Petite Chaudière Rapids, Ottawa River, and in the out-crop of the Black River limestone, near Mile End, St. Lawrence Street, Montreal.

GYROCERAS (LITUITES) AMERICANUM.

Description.—Tube long, slender, gradually tapering; section semi-elliptical; dorsal aspect nearly flat; side and ventral aspect convex, and ornamented with prominent annulations, which, in leaving the lateral angles, are at first deflected towards the aperture at a sharp angle, and then curved towards the apex, crossing the ventral side nearly at right angles to the length, or with but a slight undulation towards the apex. These annulations are upon the average five lines and a-half distant, from the summit of one ridge to that of the next, the intervening spaces being regularly convex; the surface is further marked by coarse striæ following the curves of the lateral and dorsal annulations; on the flat dorsal surface, where these latter do not appear, the striæ curve in the direction of the smaller extremity of the fossil. The dorso-ventral and lateral diameters appear to be about equal in the fragments examined, which are however somewhat distorted; the siphuncle is small and slightly eccentric, being nearest the dorsal aspect; the septa are convex and distant four lines.

The length of the longest fragment measured along the outside curve is twelve inches, its greatest diameter one inch and a-half and the least one inch, thus tapering at the rate of about half-a-line to the inch; at least one-third of the outer whorl remains, and shews by its curvature that the diameter of the discoidal spire was four inches and a-half nearly.

This species is closely allied to *Lituites giganteus*, Sowerby, but differs in its more round dorsal aspect, and in the annulations being extended quite across.

Locality and Formation. — Upper Silurian, Port Daniel, Gaspè.

Collector.—Sir W. E. Logan.

Genus Ascoceras, (Barrande.)

Ascoceras Canadense.

Description. — The only specimen yet collected of this species consists of the lower half, in a very perfect state of preservation, but totally denuded of the external shell; it shews that from the centre or below that level, where the septum of the last chamber crosses the body, the form was ventricose or broad oval, widest at about one-third the distance from the upper septum to the base, and thence decreasing with an elliptical outline to the rounded bottom; the transverse section across the broadest part is sub-elliptical, the back being much flatter than the ventral side; a side view shews the outline of the ventral aspect much more prominent and regularly ventricose than the dorsal; measured from the base to the line of the upper septum, the length of the lower part of the fossil is two inches and two lines; the width at three-fourths of an inch below the upper septum is one inch and eleven lines; the depth or diameter through, from the most prominent point of the ventral to the dorsal side, is one inch eight lines. There are only three air chambers in this species, the edges of the septa between which cross the back at about one-third of an inch from the base, girding a little more than one-third of the circumference of the fossil at that place; they then turn a short rounded angle and ascend the sides, and turning again cross the ventral aspect at the following levels: the upper septum two inches and two lines from the base, the second two lines below the upper, and the third six lines below the second. In crossing the ventral side the course is at right angles to the longitudinal axis of the fossil, and the upper two occupy more than one-half the circumference, the lower less than one half.

Where they cross the back, the edges of the three septa are much approximated, scarcely one-fifth of a line distant from each other; but after turning the angles near the base on either side they diverge from each other in ascending, so that the upper angle made by the first is three lines outside that made by the second, which latter is again six lines outside of that made by the third; in ascending they at first curve backwards, and in the upper part of their course, as they approach the upper angles they are arched gently forward. The siphuncle is small and situated one line from the centre of the base towards the dorsal side.

Locality and Formation.—Lower Silurian, English Head, Anticosti.

Collector.—J. Richardson.

GOMPHOCERAS SUBGRACILE.

Description.—Moderately ventricose, greatest thickness at about mid-length; section elliptical, diameters about as 17 to 15, dorsal outline much curved from the aperture to the apex, ventral side moderately arched, nearly straight; septa convex, two lines and one-third distant length about; three inches, diameters in the middle seventeen and fifteen lines; depth of chamber of habitation, which is much contracted at the aperture, one inch and two lines.

The general form of this species is very like that of *Oncoceras constrictum*, (Hall) but the oral extremity is more rounded, and although the shell of the specimen examined has completely disappeared yet there is sufficient evidence that the aperture was lobed like that of a *Gomphoceras* or *Phragmoceras*; in *Oncoceras* it is oval.

Locality and Formation.—Upper Silurian, Port Daniel, Gaspe.

Collector.—Sir W. E. Logan.

GOMPHOCERAS OBESUM.

Description.—Section elliptical; dorso-ventral greater than the lateral diameter in the proportion of five to four; general

form compressed, ventricose, turbinate; septa convex, about three lines distant; length about four inches; depth of chamber of habitation one inch; greatest diameter (at the second and third chamber) two inches and a-half; lateral diameter at the same place two inches; above this level the size diminishes to the diameters of one inch and one inch and a-half, which appear to be the dimensions of the aperture. Below, tapering ventricosely to a rounded point; neither the siphuncle nor the character of the surface markings of the shell is indicated by the specimen.

The specimen is imperfect at both ends, and it appears also to be slightly compressed laterally. Sufficient does not appear to decide positively upon its generic place, but it appears to me to be more allied to *Gomphoceras* than to *Phragmoceras*. Viewed laterally, it has a short, stout, somewhat heart-shaped form, while looking at the dorsal or ventral aspect, the outline is long, oval, and most pointed below.

Locality and Formation.—Lower Silurian, three miles east from Charleton Point, Anticosti.

Collector.—J. Richardson.

Genus CYRTOCERAS, (Goldfuss.)

CYRTOCERAS SUBTURBINATUM.

Description.—Short and stout, four or five inches in length; about two inches in width at the mouth; tapering at the rate of about one line to the inch from the aperture to the centre of the length, thence rapidly diminishing to the apex; section elliptical; one specimen broken through at the middle of the length is one inch nine and a-half lines in the greatest diameter, and one inch six lines in the smaller. The specimens are but slightly curved, and the greatest diameter is transverse to the direction of the curvature; siphuncle near the margin, in the centre of the dorsal aspect; small in its passage through the septa, but dilated to the diameter of four lines in the upper chambers, apparently less in the lower; septa but moderately arched, seven or eight to the inch.

This species is allied to *C. macrostomum* (Hall), but is not so much curved, and has an elliptical section, the major axis of the ellipse being at a right angle to the plane of the curvature; *C. macrostomum* is circular in the section, or if elliptical, as appears by one of Professor Hall's figures, the greater diameter corresponds to the shorter in our species.

The specimens are imperfect at both extremities, and denuded of the shell; neither the form of the apex, nor that of the aperture, nor the character of the surface, has been seen.

Locality and Formation.—Lower Silurian. Mingan Island, near Tower Rock, South-east side of Large Island of Bayfield's Chart.

Collector.—J. Richardson.

CYRTOCERAS SIMPLEX.

Description.—Slightly compressed laterally; section oval; dorso-ventral diameter greater than the lateral in the proportion of eleven to nine nearly; dorsal aspect obtusely rounded angular; ventral more obtusely convex than the dorsal. Septa ten to the inch, measured on the sides, where they are broadly but slightly undulated towards the apex; more acutely undulated on the dorsal aspect towards the aperture; curvature more than half-a-whorl; depth of chamber of habitation about equal to the greatest diameter of the aperture; siphuncle small, dorsal, dilated between the septa.

The cast of the interior shows a shallow concave constriction four lines in width, encircling the fossil close to the aperture; the rate of tapering is about one line to the inch for one-half of the length, but becomes greater towards the apex.

The dorsal curvature for two inches of the larger extremity lies nearly in a segment of the circumference of a circle, of which the radius is one inch eleven lines, thence the curve becomes more rapid, until at the length of four and a-half inches, the distance between the extremities of the ventral side of a specimen (imperfect at the small end) is one inch eight lines. The diameters at the aperture of this specimen are

eleven lines and a-half, and nine lines; at the small imperfect end, six lines and five lines respectively. The plane of the aperture is at right angles to the central axis of the fossil. This species is not so much compressed laterally as *C. falx*, neither is it so rapidly tapering, nor so much curved.

Locality and Formation.—Black River limestone. Lot N. concession A. Nepean.

Collector.—J. Richardson.

CYRTOCERAS FALX.

Description.—Laterally compressed, section an ellipse somewhat acuminated at either end; diameters as seven to ten; sides broadly convex; dorsal and ventral aspects more acutely rounded than the sides; septa much arched in the direction from the ventral to the dorsal aspects; in crossing the latter they are strongly undulated towards the aperture; siphuncle small, dorsal; general curvature very slight near the oral extremity, but amounting to more than two-thirds of a whorl in the last two inches in length of the small end. The specimens examined do not shew the distance of the septa. The surface of the shell appears to have been striated transversely. A specimen which measures three inches in length along the outside curve tapers from ten lines to three in the dorso-ventral diameter, and from seven and one-third to two and one-third lines in the lateral diameters.

Fragments of this species cannot be well distinguished from those of *C. simplex*, unless by attention to the form of the section, which in this species is about equally narrowed at either end, while in *C. simplex* it is more rounded on the ventral than on the dorsal aspect.

Locality and Formation.—Black River and base of Trenton. Pauquette's Rapids, River Ottawa.

Collector.—Sir W. E. Logan.

CYRTOCERAS REGULARE.

Description.—Section circular, curvature half-a-whorl; the oral one inch and a-half of the length, lying in the circumfer-

ence of a circle, of which the radius is one inch three lines in the specimens examined; thence curving more rapidly to the apex, which is approximated to within half-an-inch of the aperture in specimens with an outside length of three inches; depth of external chamber equal to the diameter of the aperture; tube regularly tapering at the rate of one line and a-half to the inch; siphuncle small, dorsal, dilated between the septa, which are very slightly concave and one line distant from each other where seen near the large extremity; the surface appears to be smooth.

The largest specimens seen are three inches in length and seven lines in diameter at the aperture; depth of chamber of habitation eight lines on the dorsal margin and six and a-half on the ventral; the plane of the aperture is oblique to the axis of the shell, the ventral margin being most approximated to the apex.

The proportions of this species are almost identical with those of *Cyrtolites filosum*, (Hall, Pal. N. Y., vol. 1, page 190. plate 41, fig. 38,) except as to the length. The specimens from Pauquette's Rapids appear to be full grown, and yet the largest is only about three inches long, while the specimen of *Cyrtolites filosum* figured by Professor Hall is fully four inches. At present I think these two species distinct, ours being smaller, and having a smooth surface.

Locality and Formation.—Black River and base of Trenton. Pauquette's Rapids.

Cllectors.—Sir W. E. Logan, J. Richardson, E. Billings.

CYRTOCERAS SINUATUM.

Description.—Compressed laterally, section elliptical, diameters as eleven to nine, tapering at the rate of about two lines and a-half to the inch; surface annulated with apparently sharp ridges one-third of a line wide at base, and separated by shallow regularly concave spaces one line in width, which in crossing the dorsal aspect make a strong undulation or sinus towards the apex; curvature, amounting to half-a-whorl or more, lying in the circumference of a circle, with a radius of

one and a-half inches for two inches from the aperture, thence more rapid.

The specimen examined has a dorso-ventral diameter of one inch at the aperture, and a lateral diameter of nine lines and three-quarters; the length of the dorsal margin is three inches, and in that distance it tapers to the diameter of from six to five lines. Neither the septa nor the siphuncle is visible. In some respects this species resembles *Cyrtoceras annulatum*, (Hall, Pal. N. Y., vol. 1, page 194, plate 41, fig. 485,) but in that species the section is circular, and the rate of tapering is not so great as in this, while the specimens figured on the plate cited are more sharply curved.

Locality and Formation.—Black River limestone. La Petite Chaudière.

Collector.—E. Billings.

Genus ORTHOCERAS.

ORTHOCERAS ANTICOSTENSE.

Description.—Elongated, large, section sub-oval, dorsal side broad, flattened or but moderately convex; siphuncle large, marginal, lying along the central axis of the dorsal aspect, much dilated between the septa; the rate of tapering varies in different parts of the same individual, being more rapid near the aperture than it is near the smaller extremity. From a diameter of three inches and one-eighth, measured across in the broadest direction, one specimen contracts to two inches and a-quarter in a length of six, or at the rate of about one line and a-half to the inch; further towards the apex the rate becomes gradually less. The septa are convex, about five lines distant from each other, and in crossing the dorsal side make a strong undulation in the direction of the apex.

In one fragment deprived of the shell, the character of the surface appears to have been impressed upon the cast of the interior, and if this supposition be correct, then the exterior of the shell was ornamented by sharp longitudinal raised lines, about two in one line, with finer ones between.

This fine species is most closely allied to *O. tenuifilum* (Hall) of the Black River limestone, but differs in being much flatter upon the dorsal side, and in not so rapidly expanding near the aperture; the undulations of the septa also are more pronounced, the striation of the surface apparently stronger, and the whole proportions more slender. It appears to have grown to the length of two feet and a half.

Locality and Formation.—Lower Silurian. Charleton Point, Anticosti.

Collector.—J. Richardson.

ORTHOCERAS FORMOSUM.

Description.—Section circular, tapering at the rate of one line and a-half to the inch; siphuncle one-third the diameter from the margin, small in its passage through the septa, and dilated in the chambers; septa much arched from the ventral to the dorsal margin, but moderately so in the direction of the lateral diameter; their edges strongly undulated towards the apex on the sides, and in an opposite direction on the dorsal and ventral margins; this curvature is also greater on the ventral than on the dorsal margin, the septa being a little oblique, or more approximated to the aperture on that side; proportional depth of the chambers varying from one-fifth to one-seventh of the diameter in the same individual; surface stri·ted longitudinally by fine sharp parallel raised lines, about six or eight in one line.

In one specimen two inches and a-half in length, one inch in diameter at the large, and nine lines at the small end, the distance of the septa from each other averages two lines and a-half, there being twelve in a length of two inches and a-half. In another specimen one inch and a-half in diameter, the average, is the same; and in a third with a diameter two inches, the distance is four lines. The centre of the siphuncle in this latter specimen is five lines distant from the ventral margin, where the diameter is sixteen lines.

The dilatations of the siphuncle constitute small compressed nummuloid beads three lines in diameter.

Locality and Formation.—Lower Silurian. English Head, Anticosti.

Collector.—J. Richardson.

ORTHOCERAS XIPHIAS.

Description.—Very much compressed, two-edged; lateral diameter greater than the dorso-ventral, in the proportion of fourteen to six; ventral aspect slightly convex, nearly flat; dorsal broadly rounded, but somewhat angular along the central line; sides represented by two obtuse edges; siphon small, marginal, lying along the central axis of the ventral aspect; septa much arched, and distant a little more than two lines from each other, where the lateral diameter is one inch and a quarter; the edges or lateral margins taper or incline towards each other at the rate of about two lines to the inch. the dorsal and ventral sides at one-half that rate; the septa, in a fragment one inch five lines in width, are so arched that they form an arc of a circle, of which the radius is nine lines nearly.

The specimens are imperfect and do not exhibit the character of the surface. In general form this species resembles a large *Theca*. A fragment one inch five lines in width at the larger extremity, one inch and two lines at the smaller, is one inch and a-half in length, and when perfect was apparently about nine inches long. The chamber of habitation in this specimen appears to have been one inch in depth.

Locality and Formation.—Lower Silurian. Cliffs east of English Head, Anticosti.

Collector.—J. Richardson. Trenton limestone, City of Ottawa, A. Murray.

Note.—This species has not the double curvature of the septa of *Gonioceras*.

ORTHOCERAS BALTEATUM.

Description.—Section circular, tapering at the rate of about one line to the inch; siphuncle small near the centre; septa moderately convex and a little oblique, their margin nearest

the aperture on the ventral side; surface longitudinally striated with extremely minute lines, about twelve in one line; girt with strong annulations, with acutely rounded edges, two lines distant at a diameter of seven lines, one line distant at a diameter of four lines and a-half; the intervening annular sulci are regularly concave from the edge of one annulation to another, and slightly undulated towards the aperture on the dorsal side.

Formation.—Lower Silurian.

Locality.—English Head, Anticosti.

Collector.—J. Richardson.

ORTHOCERAS MINGANENSE.

Description.—Cylindrical, tapering at the rate of less than half-a-line to the inch; siphuncle small, one-third the diameter from the margin, slightly expanded between the septa into slender fusiform beads; septa moderately arched, a little more than one line distant from each other at a diameter of nine lines; surface with strong rounded annulations, with concave annular sulci between, nearly direct, but slightly undulated, ten in one inch at a diameter of nine lines.

Differs from *O. balteatum* in its more approximate annulations, and more gradually tapering form.

Locality and Formation.—Lower Silurian.—Mingan Islands, near Tower Rock, South-east side of Large Island, of Bayfield's Chart.

ORTHOCERAS PERANNULATUM.

Description.—Section circular, very widely and strongly annulated, tapering at the rate of a little more than half-a-line to the inch. Siphuncle moderately large, central; septa regularly but not much arched, distant three lines from each other at a diameter of eight lines, annulations very prominent, sharp, a little oblique, and four lines distant at a diameter of one inch; the intervening sulci are regularly concave from the edge of one annulation to another.

Locality and Formation.—Lower Silurian. West-end, Anticosti.

Collector.—J. Richardson.

Orthoceras proprinquum.

Description.—Large, section circular, tapering at the rate of one line to the inch; septa very convex, slightly undulated at their edges, and distant two and a-half lines on an average at a diameter of three inches. The above are all the characters that can be gleaned from the very imperfect specimen examined, which, however, clearly indicates an othoceratite of great size and length, with the septa very closely approximate in proportion to the diameter. The fragment is seven inches long, and tapers from three and a-half inches to two inches eleven lines, and exhibits the edges of thirty-five septa.

Locality and Formation.—Lower Silurian. Charleton Point, Anticosti.

Collector.—J. Richardson.

Orthoceras Lyelli.

Description.—Cylindrical, smooth, section circular, tapering at the rate of one-third of a line to the inch; at a diameter of eight lines there are twelve moderately convex septa to the inch, and the centre of the siphuncle is two and one-third lines from the margin. The species is remarkable for its cylindrical, straight, and very slightly tapering form.

Locality and Formation.—Lower Silurian. Cliff East of Salmon River, Anticosti.

Collector.—J. Richardson.

Orthoceras Sedgwicki.

Description.—Section circular, tapering at the rate of nearly two lines to the inch from a diameter of three inches. Siphuncle large, marginal, dilated between the septa; septa convex, slightly undulating towards the apex on the ventral side, dis-

tant from each other four and a-half lines, and two and a-half at two inches; surface striated longitudinally. In a specimen seven inches long, three inches in diameter at the large end, and one inch ten lines at the smaller extremity, the siphuncle is one inch in diameter where seen at the small end. The striation of the surface is but very obscurely indicated in the specimen. This fine large species is allied to *O. tenuifilium* of the Black River limestone, and also to *O. Anticostense*, from both of which however it differs in its circular section and straight sides.

Locality and Formation.—Lower Silurian, West End, Anticosti.

Collector.—J. Richardson.

Orthoceras canadense.

Huronia vertebralis, (Stokes).

Description.—Extremely elongated, very gradually tapering; septa distant; siphuncle large, dilated only in the upper part of each chamber, where it forms a strong projecting annulation abruptly rounded on the upper side, and gradually sloping to the lower; depth of chambers near the aperture about one inch and a-half, becoming gradually less in the direction of the apex, somewhat variable; diameter of the non-dilated portion of the siphuncle about equal to the distance of the septa, often a little greater, sometimes a little less.

In consequence of the peculiar mode of dilatation of the siphuncle (the only part of this remarkable fossil which is well known,) it resembles a long, slowly-tapering, many-jointed column, each joint having a truncated sub-pyriform shape, its smaller extremity fitting into the centre of the large expanded upper termination of the next succeeding segment. The inferior half or two-thirds of the length of each joint is either cylindrical, or but very gradually expanding upwards with an inward and outward curve, until it finally has swollen out to form the lower sloping sides of the annulation above. A specimen from the north-west side of the Island of Anticosti, (where it is associated with fossils of Upper Silurian age, many

of them identical with species peculiar to the Niagara and Clinton groups,) consisting of six segments, corresponding to six chambers of the animal to which it belonged, is four inches and seven lines in length, giving nine lines and one-sixth as the average distance between the septa; the diameter of the uppermost annulation is one inch and four lines, and of the lowermost one inch and two lines; the rate of tapering therefore of this *Orthoceras*, as indicated by that of the siphuncle was about half-a-line to the inch, and consequently the perfect individual was in all probability six feet in length.

The specimen is fractured longitudinally, so as to exhibit a good section through four of the segments; it shews a small slightly eccentric tube one and a-half lines in diameter, with its centre filled with dark-coloured matter, apparently the same in composition as the rock in which the fossil had been imbedded, a small portion of which still adheres to one end of the specimen. With the exception of the contents of this tube, the whole siphuncle is composed or filled with a whitish calcareous spar, with however, several small druses lined with semi-transparent crystals; into these cavities small quantities of the dark-colored rock have also penetrated. At the upper end of each segment, just where the joint above appears to be inserted, a thin plate penetrates from the outer shell into the now filled-up cavity of the siphuncle, curving downwards; these appear to me to be the edges of the septa, and if so, then as in every other species of *Orthoceras*, with a dilated siphuncle, the passage from one chamber to another was smaller than the main body of the tube (in this instance about four lines less in diameter than the cylindrical portion, and from eight to ten less than that of the fully developed annulations.)

It can be clearly seen in this specimen that upon each of the inner edges of the septa there is a reniform mass, of a color a shade deeper than that of the general filling of the tube; it is placed with its constricted side against the inward projecting edges of the septum, and seems to curl around it above and below. The same arrangement of the different materials in the interior of these fossils is well figured in the Transactions of the Geological Society, vol. 5, plate 60, Figs.

2, 6, 3, in illustration of Mr. Stokes' paper on the *Orthocerata;* although at the time of the date of that memoir the meaning of these curving shades of color was not understood. Since, however, the publication of M. Barrande's investigations upon the subject, * they have become perfectly intelligible, and enable us to decide from the internal structure alone of this fossil, that it is really, the siphuncle of an *Orthoceras*, only differing from an ordinary form by the circumstance *of its being dilated in the upper part of each chamber*, so as to produce a series of top-shaped joints, instead of the row of spherical or nummuloid joints usually to be seen in the figures of different species of *Ormoceras* described in various works. This mode of dilatation in the siphuncle of an *Orthoceras*, so far from being of generic importance, is not always of specific value, because there are specimens in the collection of the Survey which exhibit both turbinate and nummuloid joints in the same individual. While upon this subject, I beg to give the following compilation of the history of the genus Huronia.

This genus was first described in a paper entitled "Notes on the Geology and Geography of Lake Huron," read before the Geological Society, in 1823, by Dr. Bigsby, who had then recently returned from his travels in North America. His memoir is full of interesting information, and the palæontological portion of it may be considered as the first essay of any importance upon the fossils of Canada. It was prepared, I believe by the late C. Stokes, Esq., who thus correctly describes the species in question, but under the impression that the specimens examined by him were corals.

"The corals of the species represented in plate 28, fig. 2, have in their general appearance a considerable resemblance to vertebræ; they are columns tapering from the top, composed of similarly formed joints, which diminish downwards both in length and breadth, though not in regular graduation. The length of each joint in this species is about one inch, and the breadth exceeds the length; the transverse section is circular. The lower or middle part of each joint is cylindrical, or slightly conical; the upper part swells out and is inflected

* See a paper by M. Barrande in the Bulletin of the Geological Society of France, dated 23rd April, 1856, and entitled "*Remplissage organique du siphon dans certaines cephalapodes paléozoiques.*"

inwards at the top, so as to meet entirely the base of the joint next above it. The dilated part is in different species in very variable proportion to the rest of the joint; the lower part of one joint is inserted to some little depth into the upper part of the next beneath it, so as to attach the joints firmly to one another. The external surface is covered over with a thin smooth coat, but this is rarely preserved, and then only in small portions; the surface is usually without this coat, and is then longitudinally striated.

"When the joint is most dilated a thin horizontal septum, formed by the abrupt inflexion inwards, and coalescence of the upper and lower parts of the outer coat, passes transversely across the joint, as is seen in two of the joints in fig. 2." (Transactions of the Geological Society, N. S., vol. 1, page 202, Plate 28, fig. 2.)

The thin horizontal septum mentioned in the above extract as occurring where the joint is most dilated, is well shewn in all the joints of our specimen, and is without doubt the remains of the ordinary septum of an *Orthoceras*. It does not extend through the siphuncle, but only penetrates inward about two lines, curving downwards as previously stated.

He proceeds to describe five species under the names of *Huronia Bigsbii*, *H. vertebralis*, *H. turbinata*, *H. obliqua*, and *H. spheroidalis*. The greatest length of any column he had seen was twenty-seven inches. The first and second of these appear to me to be of one species, *H. vertebralis*, or *Orthoceras Canadense*, as it is now proposed to call it.

As I understand him the specimens were from the quartzose limestone at Collier's Harbour, from the west end of the Great Manitoulin, and also from Drummond Island.

Afterwards, in a paper entitled "On some species of *Orthocerata*," read June 6th, 1837, and published in the third volume of the Transactions, Mr. Stokes announces his conviction that the Huroniæ previously described were the siphuncles of Orthoceratites. He had in the interim examined numerous specimens of other species of undoubted Orthoceratites, and found among them so many points of resemblance to Huronia that he could no longer doubt their relationship, although he thought proper to retain the generic name. The idea therefore of their being at least related to this family of the Cephalopoda is not new, but was long since seriously entertained by the first geologist who studied them attentively.

In the excellent little "Manual of the Mollusca," by S. P. Woodward, published in Weale's scientific series in 1851, part 1, page 89, there are two figures of Huronia with the following remarks:

"Numerous examples of this curious fossil were collected by Dr. Bigsby (in 1822) and by the officers of the regiments formerly on Drummond Island. Specimens have also been brought home by the officers of many of the Arctic expeditions. But with the exception of one formerly in the possession of Lieut. Gibson (68) and another in the cabinet of Mr. Stokes, the siphuncle only is preserved, and not a trace remains of septa or shell wall. Some of those seen by Dr. Bigsby in the limestone cliffs were six feet long."

Mr. Woodward's figure *a* consists of four joints of the siphon, with the corresponding septa, and he states in a note that it was made from a specimen presented to the British Museum by Dr. Bigsby. "The septa were added," he says, "from Dr. Bigsby's drawing; they were only indicated in the specimen by colorless lines on the brown limestone." His figure *b* represents two joints, beneath each of which are curved lines indicating the existence in that specimen of the reniform patches of color seen in our specimen, and which are simply transverse sections of the solid rings of animal secretion formed around the inside of the siphuncle upon the edges of the septa, and called by M. Barrande "anneaux obstructeurs."

If then, in view of the above facts and opinions which I have thought proper to give at some length, because they tend to support the disposition here made of these remarkable fossils, the Huroniæ are really the remains of chambered cephalopods belonging to the family of the Orthocerata, another question arises; are they generically distinct from Orthoceras proper?

And upon this part of the subject it may be observed, that the Orthoceratites were at first described as being all provided with a cylindrical non-inflated siphuncle either central or subcentral, and that since the discovery of the Lake Huron fossils those with siphons swollen between the septa have been usually referred to the genus Ormoceras, a name suggested by the bead-like form of this organ.

Some of the species have also been thought to be sufficiently distinct to constitute other generic groups and hence the names *Actinoceras*, *Conotubularia*, *Orthoceratites cochleati*, *&c*. But at present there appears to be a disposition among many palæontologists to allow these subdivisions to drop out of use, and to refer nearly all the species to the old genus Orthoceras. Thus M. Barrande, after examining nearly 300 species of palæozoic cephalopoda, has announced his intention to keep together, under the name Orthoceras, all the straight forms, whatever position the siphuncle may take, "*and no matter whether it be cylindrical or swollen between the septa.*"*

The specimens in the collections of the Geological Survey of Canada show a regular transitional series, from those with siphons scarcely at all inflated, to those with annulations an inch and a-half in diameter. The segments are also either fusiform, globular, oblate, spheroidal, nummuloid, turbinate, or more swollen at one side of the chamber than at the other. Some of these forms are also apparent in two other genera. Thus in *Gyroceras magnificum* the siphon between the septa is dilated into a series of fusiform beads; in *Cyrtoceras regulare* the expansions are globular but scarcely two-thirds of a line in diameter; in *Cyrtoceras subturbinatum* globular, four lines in diameter, and exhibiting radiating lamellæ; while in one fragment of a species of *Cyrtoceras*, not described, it is expanded in the upper part of the chamber, and tapering below exhibits a form very like Huronia.

These specimens shew that it is absolutely impossible to draw a line between those species which should be referred to *Ormoceras* (provided that genus be retained) and those which belong clearly to *Orthoceras* proper. It is equally difficult to separate Huronia from *Ormoceras*. In the best-known species of this latter genus *O. tenuifilum*, Hall, good specimens show that the siphuncle is constructed on precisely the same plan as Huronia, with this difference only, that the inflation occurs in

* See a paper in the Quarterly Journal of the Geological Society of London, Vol. 10, page 6 of the "Translations and Notices," entitled "*On the Silurian Crustacea, Pteropoda, and Cephalopoda of Bohemia.*" By *M. J. Barrande*.

the lower part of the chamber. One beautiful example from the township of Fitzroy is completely silicified. It was originally imbedded in limestone, and thus by treatment with hydrochloric acid it became possible to remove completely the calcareous matter, leaving eight segments of the siphuncle perfect, and the corresponding chambers entirely empty. The length occupied by the eight chambers is three inches and one-eighth, the lateral diameter at the small end is one inch, at the large end one inch ten lines; the distance between the septa is pretty uniformly five lines, agreeing in this respect with fig. 2, plate 17, Pal. N. Y., Vol. 1, which Professor Hall refers to the variety *O. distans*. The septa appear to spring from the edges of the annulations of the siphon, but in one instance there is some evidence of an origin in the constriction below. The greatest expansion of the swollen portion of the siphuncle is just within the concavity of the septum, as expressed by Professor Hall, and on its upper side it first slopes with a rounded outline, and then ends suddenly with a perpendicular contraction to the small cylindrical portion, which is continued about one and a-half lines, and then gradually expands to form the next inflation above. Were all traces of septa and shell removed, this siphuncle would at once be called a Huronia. In another more slender specimen, also silicified, and prepared by the same process, the septa are only about three lines distant, and yet the Huronia form of the siphuncle is very perfectly exhibited, and moreover the septa seem to originate from the lower part of the constricted portion, immediately in contact with the base of the projecting shoulder-like upper margin of the next expansion below; they seem to be funnel-shaped and to contain the siphuncle, only branching away from it from the circumference of the annulations on the lower side. If this be the true interpretation of the appearances presented by these specimens, then the points of the insertion of the edges of the septa into the siphuncle, or rather of their attachment to it in these species, are the same as in *Huronia*.

In the next species to be described, *O. persiphonatum*, the siphuncle is on one side a perfect Huronia in appearance.

It consists of a regular series of joints, each broad at the top and diminishing downwards, the smaller end of each joint inserted into the larger extremity of the one next below. There are no traces of septa except just at the upper end of the joint, and there only so much as is seen in *Huronia vertebralis*, that is to say, "the thin horizontal septa" first observed by Mr. Stokes. Judging from this side we could only classify the specimen as an additional species of Huronia, but on examining the other side we find two of the septa remaining, and the perfect cast of the interior of the external shell, for the length of one of the chambers. It also shows that the septa were excessively thin, and although expanding from the edges of the annulation, as in *O. tenuifilum*, they originate from the base of the expansion next below; the three specimens have also the central slender tube of Huronia. The same organ may be seen more or less distinctly in almost every section of the siphuncle of *O. tenuifilum.*

It appears to me therefore that these several species only differ from each other specifically in the form and position of the inflated portions of their siphuncles, and that all the species of Huronia should be referred to the genus *Ormoceras*, provided that genus be retained; but if it be suppressed, that they should then be classified in the old genus *Orthoceras.* In removing this species to its new place it would be desirable to retain for it one of the original specific names, and I would call it *Orthoceras vertebralis*, were it not that there are already several species of that name. There is also one *O. Bigsbyi.* As it was first discovered in Canada, and as it has always been associated with the geology of Canada, I beg therefore to propose for it the name of *O. Canadense*

Locality and Formation.—Middle Silurian, South-west Point of the Island of Anticosti.

Collector.—J. Richardson.

It occurs also in the same geological position on the Great Manitoulin and Drummond Islands, Lake Huron.

Orthoceras persiphonatum.

Description.—Elongate, large; siphon of great size, marginal; strongly annulated in the upper-half or two-thirds of each chamber, and cylindrical or but gradually expanded in the lower third; septa very thin and convex, distant six and a-half lines on an average when the siphuncle has a diameter of one inch and a-half.

The annulations of the siphuncle are in the two specimens examined, a little oblique, the ventral margin being nearest the aperture; a fragment of a siphuncle six inches and a-half in length tapers from one inch and a-half to one inch and a-quarter, or at the rate of about half-a line to the inch.

This species differs from *O. Canadense* only in its more approximate septa, and appears to have been like that, an extremely long, tapering form, with very thin, fragile, exterior shell and septa.

Locality and Formation.—Middle Silurian. Cormorant Point, Anticosti.

Collector.—J. Richardson.

Orthoceras cornuum.

Description.—Section circular, tapering at the rate of one and a-half lines to the inch, from a diameter of two inches and four lines; siphuncle small, eccentric, one-fourth of the diameter from the margin; septa convex, from four to six lines distant. The only specimen seen is slightly bent, and has the siphuncle approximated to the side of curvature.

The specimen is ten inches in length and two inches in diameter at the largest end. A portion of the chamber of habitation remains, and some of the septa at its base are much less distant than elsewhere. Thus the first and second are distant two-thirds of a line, and the next five about one line and a-half each, the sixth and seventh two lines and a-half, and then they become at first six lines distant, and towards the apex only four lines.

The specimen resembles *O. subarcuatum* (Hall), but no traces of the annulations occuring on that species have been observed in this.

Locality and Formation.—Lower Silurian, apparently at the base of the Trenton limestone. Tower Cliff, S. E. point of Large Island, Bayfield's Chart, Mingan Island.

Collector.—J. Richardson.

ORTHOCERAS BUCKLANDII.

Description.—Section circular, tapering at the rate of one line to the inch; siphuncle small, eccentric, dilated between the septa into globular, bead-like expansions, two lines in diameter; septa moderately convex, two lines distant at a diameter of one inch and two lines; where the fossil is fourteen lines in diameter the siphuncle is four lines from the margin.

A specimen with a diameter of twenty-two lines, has the centre of the siphuncle distant from the margin about seven lines.

Locality and Formation.—Upper Silurian. Beach west of South-west Point, Anticosti.

Collector.—J. Richardson.

ORTHOCERAS MAGNI-SULCATUM.

Description.—Tapering at the rate of two lines to the inch; septa convex, exceedingly oblique, distant one line upon an average, at a diameter of one inch four lines; surface sulcated longitudinally by about fourteen shallow concave furrows, which, at the diameter mentioned, have a width of four lines each.

The specimen is a fragment one inch and a-half in length, exhibiting only the above characters. The great width of the longitudinal furrows is a most marked character, and will be sufficient to render very small fragments of this fossil instantly recognizable.

Locality and Formation.—Lower Silurian, Charleton Point.

Collector.—J. Richardson, Anticosti.

Orthoceras Allumettense.

Description.—Section nearly circular, tapering at the rate of one line and a-half to the inch; siphuncle eccentric, dilated between the septa to the width of four lines and a-half; septa very convex, from two to two lines and a-half distant; surface apparently smooth.

The inner margins of the dilatations of the siphuncle are near-at the centre of the fossil, and are oblique; the outer margins are most approximate to the aperture. When separated, the siphon resembles *O. persiphonatum* in consisting of a series of flattened discs with rounded edges, but it is not more than one-fifth the diameter of that species. It is also less than the same organ in *O. tenuifilum*; in a specimen of this last named species, at a diameter of one inch, even the constricted portion of the siphon is nine lines, while in *O. Allumettense* the annulations have only a breadth of from four to five lines.

This species is rather common in a fragmentary condition, It occurs at Pauquette's Rapids, at the lower end of the Allumettes Island, and also in the townships of Fitzroy, Hull and Huntley, associated with Bird's-eye, Black River and Trenton limestone fossils.

The specific name is derived from the *Ile des Allumettes*, as it is in the limestone at the lower end of this island that specimens of this species have been obtained in the greatest perfection.

Formation.—Lower Silurian, Bird's-eye, Black River, and Trenton. Localities as above.

Collectors.—Sir W. E. Logan, J. Richardson, E. Billings.

Orthoceras Ottawaense.

Description.—Section circular, tapering at the rate of about one line to the inch, from a diameter of seven lines; siphuncle small, nearly central, slightly dilated; septa at the diameter of seven lines, six in thirteen lines, about ten to the inch at a diameter of four lines; they are rather convex and a little oblique, their dorsal margin most approximate to the aperture.

The siphon appears to be more eccentric towards the apex than it is near the aperture. At a diameter of two lines and a-half, its centre is one line and a-half from the centre of the fossil, but at the diameter of seven lines it is very nearly central.

This species somewhat resembles *O. recticameratum* (Hall), but differs in its regularly convex and distant septa. In the figure of that species, Pal. N. Y., vol. 1, plate 2, figure 4, at a diameter of seven lines there are nine septa to the inch, and they are described by Professor Hall, as not curved, but passing obliquely in a line from the inside of the shell to the siphuncle, or *vice versa*. In one specimen at the same diameter there are scarcely six chambers to the inch, and the septa have a well rounded convexity of more than one line in height.

The specimen from which the above description has been drawn was collected at La Petite Chaudière Rapids, on the River Ottawa, where it occurs associated with numerous species of fossils of the Black River and Trenton limestones; but in the vicinity of the Union Bridge, two miles further down the river, numerous fragments occur in the central part of the Trenton, which have the same proportions, and appear to me to be the same species. In this latter locality they are replaced and often filled by crystalline dolomite weathering of a light red color. The specimens are usually from four to five inches in length, rarely more than six inches, and almost always consist of the smaller extremity of the fossil.

Orthoceras murrayi.

Description.—Section sub-elliptical or obscurely triangular, tapering at the rate of one line and a-third to the inch, from a lateral diameter of thirteen lines; ventral aspect the broader; flattened or but slightly convex; dorsal side most convex along the centre, giving to the section a sub-triangular shape; lateral diameter greater than the dorso-ventral in the proportion of about eleven to thirteen; siphuncle cylindrical, one-sixth of the greatest diameter of the fossil, situated near the

ventral margin. The septa on the ventral side make a strong curve towards the apex; they are distant from one-seventh to one-tenth of an inch. In a specimen three and a-half inches in length and thirteen lines wide at the largest end, in the first inch of the smaller extremity there are not quite seven septa; in the next inch the same number, in the third nine, and in the half-inch five. Another specimen shews ten septa to one inch, at a diameter of thirteen and a-half lines, and in a third there are nine at a diameter of one inch; they are moderately convex. An artificial section through five of the chambers shews that the siphuncle is cylindrical, and that the septa, at the point of their contact with, it are bent suddenly towards the apex; the surface, which is not well shewn, appears smooth. The species is named after Alexander Murray, Esq., Assistant Provincial Geologist, who discovered it.

Localities and Formation.—Trenton limestones, north and east sides of St. Joseph's Island, Lake Huron.

Collector.—A. Murray.

ORTHOCERAS HASTATUM.

Description.—Shaped like a *Theca*, two-edged; ventral side broad and almost flat, slightly convex; dorsal aspect most convex along the centre, thence sloping to the sides, which are perpendicular to the ventral aspect, and nearly flat in the larger portion of the shell. The section is thus a low, broad-based triangle, with the angle at each end of the base truncated, and with the apical angle rounded. At a lateral diameter of eleven lines the height or dorso-ventral diameter is six lines; the rate of tapering is about four lines to the inch, measuring the inclination of the sides; the ventral and dorsal aspects approach each other at the rate of two lines and a-third to the inch; siphuncle small, close to the centre of the ventral margin; the septa are curved in a circle of which the radius is about half-an-inch, their distance from each other has not been satisfactorily ascertained; near the apex the sides consist of two rounded edges, but in the direction of the aperture

these become more and more broadly truncated, until at a diameter of eleven lines they have a perpendicular width of about two lines. The surface is coarsely striated transversely, and at the dorsal ridge, the striæ appear to make a bend towards the aperture.

Locality and Formation.—Black River, and Trenton limestone, Pauquette's Rapids, Ottawa City.

Collectors.—Sir W. E. Logan and E. Billings.

This species tapers more rapidly than *O. xiphias*, and judging from the size of one fragment must have attained a length of six inches.

ORTHOCERAS ROTULATUM.

Description.—Septa very convex, four lines distant at a diameter of one inch eleven lines; siphuncle large, dilated between the septa, constituting an obliquely nummuloid cylinder fourteen lines in diameter, where the diameter of the perfect fossil was two inches, and situated within three lines of the ventral margin. The annulations have an obliquity of about 20° to the longitudinal axis, and they are evenly convex from one septum to another.

A silicified specimen from which all the calcareous matter has been removed by the application of hydrochloric acid, shows the rings of obstruction to be contiguous, the line of contact between each two being near the centre of the dilatation on the dorsal side of the siphuncle, and a little in advance of the centre on the ventral side, where also they have the greatest thickness. The fragment appears to be the oral extremity of the siphuncle, and four of the rings at the entrance are still incomplete on the dorsal aspect, the last-formed having made the least progress at the time of the death of the animal. The acid has also removed from the interior all the limestone, leaving the inside of the rings exposed. They are transversely wrinkled or deeply striated in the general direction of the length. The diameter of the internal tubular cavity of the siphuncle is in this specimen six lines at the extremity, but it contracts to about two lines after penetrating three inches

(the length of the fragment), and it then contains a second small tube one line in diameter. Another specimen, two inches and a-quarter in length, is fourteen lines in diameter, and there is a portion of the external shell still attached to it, the convexity of which when extended into a complete circle, shows the diameter of the perfect animal to have been at this place two inches nearly. It also exhibits the strong transverse plications on the interior of the rings of obstruction, and shows that these were thickest on the ventral side. The lines of contact of the rings in this specimen are visible on the outer margins of the annulations of the siphuncle, as in the last, but appear to be nearly central all around; the small internal tube cannot be detected. This species differs from *O. persiphonatum* in the much more approximate septa, and in the uniform dilatation of the siphuncle, which in that is only expanded in the upper part of the chamber, while in this the margins of the segments are regularly rounded from one septum to another.

Locality and Formation.—Upper Silurian, Niagara Group, Head of Lake Tamiscamangue,

Collector.—Sir W. E. Logan.

ORTHOCERAS PYTHON.

Description.—Large, elongated, gradually tapering; septa very convex, distant one inch or a little more at the oral extremity, thence becoming more approximate, until at the apex they are scarcely half-an-inch apart; the siphuncle is large and dilated between the septa into a series of sub-globular or oval expansions, decreasing in size from the aperture towards the apex; these are slightly more inflated in the upper than in the lower half. At the apex in one specimen, the most perfect seen, where the septa are five lines distant, the diameter of the last bead of the siphuncle is four lines, and of the twenty-seventh from the apex eleven lines, the length being one inch; the passage through the septa is small. The separated siphuncle of this species is a fossil of a very remarkable appearance, resembling a row of small eggs placed end to end, the size gradually diminishing from the diameter of one inch

to that of three or four lines. It is one of these species which will probably not often be found with the septa and external shell preserved, as these portions of the structure appear to have been of a thin and perishable nature, while the siphuncle with the exception of a small central channel, was completely solidified by the calcareous secretion of the animal during life, and thus will perhaps be more frequently discovered well preserved.

The finest specimen known is a siphon eighteen inches in length, consisting of twenty-seven joints, corresponding to twenty-seven chambers, collected by Mr. P. A. McArthur in the Trenton limestone at the City of Ottawa. In this specimen there are no traces of septa or external shell. This, and several other fragments from the same locality, are now in the collection of the Geological Survey.

Another specimen of six segments, with a portion of the shell and traces of septa, was found by myself at the Côte des Neiges, Montreal, last summer. An artificial section shews the internal channel or tube, and also that the amount of secretion was greatest on one side, probably the ventral side.

Since the above was written, Professor Dawson, Principal of McGill College, Montreal, has given me the opportunity of examining another specimen in his collection; it consists of a fragment exhibiting on one side eleven of the expansions of the siphuncle, with traces of the septa upon the other. The specimen, although crushed, proves the siphuncle to be considerably excentric, and that the rate of tapering is almost one line to the inch. The eleven joints occupy a length of six and one-fourth inches, and they appear to belong to the terminal half of an individual of medium size. The memorandum accompanying the fossil when sent to McGill College, states that it was "Found in limestone rock, near the surface in the 14th concession of the Indian Lands, Kenyon. The surrounding country has abundance of limestone with the remains of fish or reptiles, thickly interspersed with granite boulders; the land has a great deal of sea-shell in it."

ORTHOCERAS DECRESCENS.

Description.—Shell annulated, with sub-acutely rounded and slightly undulating ridges, which are two lines distant at a diameter of fourteen lines, somewhat more approximate towards the apex; intervening spaces regularly concave and half-a-line in depth. Section circular, tapering at the rate of two lines to the inch; siphuncle small, excentric, about one-sixth of the diameter from the centre; septa concave, slightly oblique, their ventral margins nearest the aperture, distant two lines at a diameter of eleven lines.

Differs from all other described annulated species of the Silurian limestone of America in its more rapid rate of tapering.

Locality and Formation.—Black River limestone. La Petite Chaudière Rapids, Ottawa River. East side St. Joseph's Island. A. W. Smith's farm, Côte de la Visitation, Island of Montreal.

Collectors.—E. Billings and J. Richardson.

ORTHOCERAS VULGATUM.

Description.—Section circular or very slightly oval, tapering at the rate of one line and a-half to the inch; siphuncle nearly central, small; septa concave, distant from each other from two to two and a-half lines. A fragment two inches and a-half in length, fourteen lines in diameter at the large end, and ten and a-half at the smaller, has twelve chambers. A second specimen fourteen lines in diameter, has five chambers in a length of ten lines and a-half. A third, at a diameter of nine lines, has four chambers in a length of eight lines.

Locality and Formation.—Trenton limestone, Ottawa.

Collector.—E. Billings.

ORTHOCERAS HURONENSE.

Description.—About six inches long; section circular; tapering at the rate of two lines to the inch; septa moderately convex, two lines distant at a diameter of eight lines, one line

distant at a diameter of four lines; siphuncle small, central; depth of chamber of habitation one inch and a-half, slightly contracted towards the aperture, and shewing upon the cast an internal thickened ring half-an-inch wide. The surface appears to have been sulcated with shallow longitudinal furrows, one line in width, which have left their impression on the cast; this appearance, however, may be deceptive. Resembles *O. Ottawaense*, but has a more decidedly central siphuncle, while the septa are not so convex.

Locality and Formation.—Trenton limestone, east side of St. Joseph's Island.

Collector.—A. Murray, Esq.

Sub-Kingdom, ARTICULATA; *Class*, CRUSTACEA; *Order*, ENTOMOSTRACA.

Genus BRONTEUS, (Goldfuss.)

BRONTEUS LUNATUS.

Description.—Oblong-ovate, or broadly-ovate, including the spines; length two inches, width of thorax about one inch; width across the head behind the eyes one inch and a-half. Head a perfect crescent, the posterior angles being produced backwards in broad flat spines, which terminate with sharp points almost as far back as the angles of the pygidium. Glabella between the eyes, about two-thirds the width of the axis of the thorax; front of the glabella one and a-half times the width of the axis of the thorax; the sides regularly curved, the neck-furrow moderately deep, rounded at the bottom and extending quite across. Immediately above the neck-furrow the glabella is suddenly but not much elevated, and continues at nearly the same level along the centre, until within one-fifth of its length of the front, and then descends with a somewhat sudden rounded slope to the margin. The transverse furrows of the glabella are represented on each side by three barely perceptible indentations, the first two a little in advance of a line drawn across the front part of the eyes,

the second nearly on this line, and the third about as far behind as the first are before the line. The eyes are two lines in length, more than semi-circular, and one line at their base from the posterior margin; they are separated from the glabella by a rather wide deep furrow, which is angular at the bottom. The distance from the eyes to the outer margin of the head is about equal to the width of the glabella in its most narrow part. The thorax is well trilobed, the axis elevated, depressed-cylindrical, one-fourth wider than the glabella between the eyes, a little broader in the middle than at the ends, and in perfect specimens somewhat narrower than the side lobes.

This however is owing to the greater convexity of the axis, for in specimens pressed quite flat the axis is as wide as the pleuræ are long.

All the annulations are smooth, slightly rounded, and terminate in sharp falcate points turned backwards.

The axis of the pygidium is semi-oval or sub-triangular, partly terminated at rather more than one-fourth the length from the thorax, and below that point continued in a low rounded ridge, which becomes gradually broader and less prominent until it reaches the margin. There are six shallow lateral furrows on each side; the first runs nearly parallel with the upper edge of the pygidium, and at a distance therefrom of a little more than the width of the articulations of the thorax, until it has proceeded half-way to the margin; it then runs backward and soon becomes obsolete. The second originates nearly in the same point with the first, but curves backward more directly. The other four are nearly straight, and at equal distances from each other, but all disappear on their approach to the margin.

In a specimen one inch eleven and a-half lines in length, the head occupies six and a-half lines, the thorax six lines, and the pygidium eleven lines; width of glabella between the eyes three and a-half lines, of front of glabella seven lines; centre of axis of thorax four and a-half lines; of the spines in the line of the posterior margin of head four lines, and of the pygidium at its upper margin fifteen lines. The specimen is

pressed nearly flat, consequently some of the transverse measurements are exaggerated.

The most striking character presented by this species is the remarkable crescent-shape of its head. The form to which appears to be most nearly allied in this respect is *B. Partschi*, (*Barrande, Système Silurian du centre de la Bohême*, vol. 1, plate 46, fig. 19.) In that species the spines extend backwards to the points of the third pleuræ, in ours to the points of the ninth.

Locality and Formation.—Not uncommon in the central part of the Trenton limestone, at the City of Ottawa.

Collector.—E. Billings.

Genus TRIARTHRUS, (Greene.)

TRIARTHRUS SPINOSUS.

Description.—This interesting little trilobite is principally distinguished from *T. Beckii* by its spines. One of these springs from the centre of the neck-segment and extends backwards to the third or fourth segment of the body; a second proceeds from the centre of the eighth segment of the axis of the thorax, and projects back beyond the apex of the pygidium. Two others from the posterior angles of the head extend as far as the points of the seventh or eighth pair of pleuræ.

The spines are all slender, apparently cylindrical, and about one-fifth of a line in diameter.

The species is destitute of the short spines of *T. Beckii*, and in none of the specimens have I been able to detect more than thirteen segments in the thorax, and four or five in the pygidium, which is remarkably like that of a small specimen of *Calymene Blumenbachii.* In a well preserved specimen of *T. Beckii*, in the museum, there are distinctly fifteen segments in the thorax and five in the axis of the pygidium, so that if these two species be congeneric, the number of articulations in the genus must be a variable character.

Locality and Formation.—Very abundant in the Utica slate in the township of Gloucester, County of Carleton.

Collector.—E. Billings.

Genus Acidaspis, (Murchison.)

Acidaspis horani.

Description.—Broadly oval, sub-quadrilateral; length one and a half inch; width at the centre of the thorax eleven lines; surface nearly smooth, slightly granular; glabella including the side lobes oval, narrowed in front, the side lobes separated from each other by deep furrows sloping forward and outward, and from the body of the glabella by a shallow rounded groove; the central lobe on each side the largest. There are ten segments in the thorax; axis cylindrical, one-third wider at the head than at the pygidium; pleuræ with an elevated rounded ridge along their centres, on each side of which there is a shallow concave furrow. They are geniculated at a distance from the sides of the axis about equal to the width of the axis in the centre of the thorax; all the pleuræ that can be seen are terminated with long cylindrical sharp spines.

The pygidium is the segment of a circle of which the proportional length of the chord to the height is as seven and a-half to two and a-half; it is margined by a narrow sub-angular or rounded border half-a-line in width. The axis is conical, convex, terminated at the border behind; it exhibits three annulations, the first two conspicuous, rounded, and the last obscure; the first annulation is continued backwards on the lateral lobes of the pygidium and beyond the margin in the two principal spines. There are four secondary spines on each side of the principal, and six between them; they are all cylindrical and sharp pointed.

The following are the dimensions of the specimen discovered:

Length without the terminal spines,............nearly	16	lines.
Width at centre of thorax, ...	11	"
Length of glabella, ...	5	"
Length of thorax, ...	8	"
Length of pygidium, ...nearly	3	"
Width of pygidium, ...	8	"
Length of principal spines,..........................	3	"
Length of secondary spines,........................	2½	"

Of the head only the central portion is preserved. The neck-segment is mutilated, and it cannot therefore be determined whether or not there were any spines attached to the posterior part of the glabella. Detached specimens of the glabella would so much resemble the same part of certain forms of *Calymene Blumenbachii*, that they would be mistaken for that species unless critically examined.

I beg to dedicate this species to the Rev. E. J. Horan, Director of the Laval Normal School, at Quebec, who discovered and kindly communicated the specimen for description.

Locality and Formation.—Trenton limestone, Rivière à la Friponne, near Cape Tourment.

CLASS UNCERTAIN.

Genus PASCEOLUS.

The above generic name is proposed for certain ovate or sub-globular bodies resembling the *Ischadites Kœnigi* of the Silurian system, but differing therefrom in the form of the plate-like markings of the casts of the interior, which in this genus are pentagonal or hexagonal instead of quadrangular. A specimen from Anticosti shews that the animal was inclosed in a thin leather-like sack, and attached to the bottom by a short tubular continuation of this external covering. Its affinities appear to be with those of the *Tunicata.*

PASCEOLUS HALLI.

Description.—Body ovate or balloon shaped, being regularly rounded above and produced below into a short neck-like pedicle, which constitutes the organ of attachment; outer integument thin, its external surface covered with small irregular rounded wrinkles about ten in one line, distinctly visible to the naked eye; its interior reticulated with ridges corresponding to the divisions between the plate-like markings of the cast of the inside. The cast of the interior is completely covered with hexagonal or pentagonal divisions, presenting the

appearances of *Sphæronites* or *Favosites*; these spaces are each about a quarter of a line in diameter at the base of the fossil, but increase in size above, until at the summit they are one line in diameter. The spaces are convex in their centres, and the interior of the integument is fitted with concave depressions to correspond.

One specimen was procured with the integument preserved; it extends below the base, and encloses the short pedicle as well as the body above. On one side of the cast there is a small elevation about half-way between the top and bottom, which appears to mark the position of an aperture in the side of the animal. I beg to dedicate this species to Professor Hall. Length of specimens one inch and a-half, greatest diameter about the middle, thirteen lines.

Locality and Formation.—White Cliff, Gamache Bay, Middle Silurian.

Collector.—J. Richardson.

Pasceolus globosus.

Description.—Sub-globular from one to two inches in diameter; surface markings principally hexagonal, and about two lines in diameter.

Locality and Formation.—Trenton limestone, City of Ottawa, where it is found in certain quarries in great numbers, usually flattened or pressed into a hemispherical shape.

Collector.—E. Billings.

Plantæ.

Genus Beatricea.

The above generic name is proposed for certain tree-like fossils collected in the Lower and Middle Silurian rocks of Anticosti. They consist of nearly straight stems from one to fourteen inches in diameter, perforated throughout by a cylindrical and nearly central tube, which is transversely septate. Outside of the tube, they are composed of numerous concen-

tric layers resembling those of an exogenous tree. No traces of roots or branches have been distinctly observed. There appear to be two species, distinguishable only by the characters of the surface.

BEATRICEA NODULOSA.

Description.—The surface of this species is covered with oblong, oval, or sub-triangular projections from one to three lines in height, each terminating in a rounded blunt point which is nearer to one end of the prominence than to the other. Some of the projections are six or seven lines in length at the base, and half as wide. Generally they are smaller, and often with a nearly circular base; the distance between them is from one to three lines. They exhibit in some specimens a tendency to an arrangement in rows following the length of the stem. In some instances these rows wind around the stem in spirals. In addition to these characters, the whole surface is fretted with minute points, and these when partially worn show a perforation in their centres.

In a specimen three inches in diameter, the diameter of the central tube is three-quarters of an inch; the transverse septa are thin, very concave, and at distances from each other varying from one line to one inch.

Locality and Formation.—Anticosti, at Wreck Point, Salmon River and Battery Cliff. Lower Silurian.

Collector.—J. Richardson.

BEATRICEA UNDULATA.

Description.—The surface of this species is sulcated longitudinally by short irregular wave-like furrows from two lines to one inch across, according to the size of the specimen. In other respects it appears very like *B. nodulosa.* The largest specimen is ten feet five inches in length, about eight inches in diameter at the large end, and six inches and a-half at the smaller extremity. Another short fragment is fourteen inches in diameter.

All the specimens of both species are replaced by carbonate of lime, but show more or less perfectly the septate character of the central tube and the concentric arrangement of the layers of the stem. They are generally broken up into short pieces.

Locality and Formation.—Cape James, Table Head, two miles east of Gamache Bay, and numerous other localities in the Middle Silurian.

Collector.—J. Richardson.

I have the honour to be,

Sir,

Your most obedient servant,

E. BILLINGS.

REPORT

FOR THE YEAR 1853,

OF

T. STERRY HUNT, Esq., CHEMIST AND MINERALOGIST TO THE PROVINCIAL GEOLOGICAL SURVEY,

ADDRESSED TO

WILLIAM E. LOGAN, Esq., F.R.S., PROVINCIAL GEOLOGIST.

LABORATORY OF THE GEOLOGICAL SURVEY,
MONTREAL, 1*st May*, 1854.

SIR,

In my last Report I endeavored to resume the analyses of mineral waters which have from time to time appeared in the published Reports of the Survey, to classify them, and to indicate their relations to the different divisions of the sedimentary rocks. All of these springs issue from the palæozoic formations, and the greater part from the Lower Silurian rocks of Lower Canada; their distribution is highly important both in a geological and chemical point of view. You have shown that the great palæozoic basin of Canada is divided into two secondary basins by an axis extending from Deschambault on the St. Lawrence, in a direction south-west to Lake Champlain. The eastern part of the western basin is more or less affected by undulations, which appear to be connected with this great axis, and present at the same time many dislocations which you have traced for long distances, and shown to be connected with the masses of intrusive rocks so common in the district of Montreal.

It is in this disturbed region that by far the greater number of the mineral springs occur, and although it is often difficult to establish the existence or trace the extent of the faults in the stratification, on account of the quantity of quaternary and diluvial deposits which generally cover the Silurian rocks of the region, we are enabled to discover that in a great number of cases the mineral springs occur along the lines of disturbance, and it is probable that there exists a constant relation of this kind. It would appear in many cases that a very small dislocation is sufficient to give rise to springs impregnated with the mineral matters of the disturbed strata. The great western portion of the occidental basin, which is almost undisturbed, presents but very few mineral springs, although the wells which have been sunk at Kingston, Hallowell, St. Catherines and elsewhere, show that the rocky strata of this region are charged with saline waters.

As we approach the south-eastern limit of the western basin, the mineral springs become more and more numerous, but this boundary once passed, we soon reach a region where the rocks have become profoundly altered, and furnish no more mineral waters; it is however to be remarked that between the anticlinal axis which forms the limit of the two basins, and the metamorphic region on the south-east, several mineral springs occur.

The two classes into which I have in a previous Report divided the saline mineral waters, may be conveniently distinguished as the *neutral* and the *alkaline* waters. The former contain chlorids of magnesium and calcium, while in the latter the whole of these earthy bases occur the form of carbonates and silicates, the waters being alkaline from the presence of carbonate of soda. The few saline waters of the Upper Silurian rocks are all neutral, as is also the greater number of those issuing from the limestones which constitute the inferior portion of the Lower Silurian series, while the alkaline waters characterise the schistose strata which constitute its upper portion. The schists of the Hudson River group are argillaceous, and their analysis shows that they are composed to a great extent of the *debris* of felspathic rocks, and contain three

or four-hundreths of alkalies, which they slowly give up in a soluble form to the decomposing action of infiltrating waters. In this way the neutral waters of the underlying limestones have their earthy chlorids decomposed, and are converted into alkaline waters, which are still strongly saline.

There is however another class of alkaline waters in which the alkaline carbonates and silicates predominate, and which contain but a small portion of common salt. These waters appear to be derived exclusively from the argillaceous strata, and to have no connection with the underlying limestone rocks. Such are the springs of St. Ours, of the Grand Coteau of Chambly, and some of the waters of Nicolet. I have examined from the region about Nicolet, six springs which issue from the schists of the Hudson River Group along the same line of disturbance, the whole of them within a distance of three or four leagues. These waters are described in the Report of last year; two of them are strongly saline and neutral, two others are also saline but alkaline, and the remaining two are characterized by the predominance of alkaline carbonates. These last are probably waters derived entirely from the schists, while the other four have their source in the limestones.

In continuation of these investigations, I have to submit to you the results of the examination of several more mineral waters, some of which are remarkable in their composition, and serve to throw additional light upon the general conclu sions already adduced. I shall in the first place give the results of the examination of two strongly saline neutral waters from Western Canada. One of these occurs at Bowerman's mills, on the thirty-second lot of the third concession of Whitby. The spring is copious, rising to the surface and filling a large cistern, the temperature of the water in which, on the 12th of October, was found to be 51° F., but the conditions were not such as to render this a satisfactory determination, and it is probably above the truth. The water is highly saline, very bitter, and when concentrated almost acrid to the taste. It deposits by boiling a portion of carbonates of lime and magnesia, with a little strontia and traces of iron.

The water furnishes evidence of abundance of bromine, but it is only in the alcoholic extract of the salts that the presence of iodine is apparent. The analysis of the water was conducted in the usual manner, but for the determination of the bromine, the iodine having been separated in combination with palladium, the soda salts were treated with one-sixth of the amount of nitrate of silver requisite for their complete decomposition, and the precipitate, which was found to contain the whole of the bromine, was analysed by fusion in a current of chlorine, until the whole of the bromid was decomposed with the evolution of copious red fumes of bromine, the amount of which was 0·220 parts in 1000 of the water. The alkaline chlorids yield but a trace of potash salt when treated with chlorid of potassium.

The analysis of 1000 parts of the water gave as follows:

Chlorid of sodium,	18·9158
" " calcium,	17·5315
" " magnesium,	9·5437
Bromid " sodium,	·2482
Iodid " "	·0008
Carbonate of lime,	·0411
" " magnesia,	·0227
Salts of potash, strontia, and iron, ...(traces)	
	46·3038

The spring at Whitby issues from the Trenton limestone, and in the same formation in the township of Hallowell several borings have been made with a view of obtaining brine for the manufacture of salt. On the 11th lot of the 2nd concession of the township there are two salt wells on the land of Mr. Amos Hubbs, and one on the adjacent lot of Mr. Stewart Christie. The rock is met with at a depth of from six to ten feet, and the well of Mr. Christie having first been sunken forty-five feet, a boring was carried down to the depth of one hundred. The well was filled with surface water at the time of my visit, but a portion of the brine raised from the bottom of the well at forty-five feet, seemed less strong than that extracted in the same manner from a well twenty-seven feet deep, on the land of Mr. Hubbs. The latter was accor-

dingly selected for examination. It had a density of 1053·11, at 60° F., and was exceedingly bitter and saline to the taste. By boiling it deposited no carbonates; and the residue after evaporation and dessication at 300° F. was completely soluble in a cold solution of sal-ammoniac, with evolution of ammonia, showing that the portion insoluble in water was magnesia from the decomposition of the chlorid of magnesium, which, with the chlorid of calcium, is present in this brine in very large proportions. The water contains no sulphates, and only traces of potash salts; it yields a strong reaction of bromine, and unlike the Whitby spring, a large proportion of iodine. This element is so abundant as to be readily detected in the unconcentrated water, which when mingled with a solution of starch and a few drops of hydrochloric acid, becomes so deeply blue on the addition of a little nitrite of potash, as to be nearly opaque in a glass three inches in diameter. The iodine and bromine were determined as in the previous analysis; the iodine was equal to 0·01128, and the bromine to 0·3639 parts in 1000 parts, for which the analysis gave :—

Chlorid of sodium,	38·7315
" " calcium,	15·9230
" " magnesium,	12·9060
Bromid " sodium,	·4685
Iodid " "	·0133
	68·0423*

* A bottle of water sent me the summer following by Mr. Hugh McDonell, from a well on the 17th lot of concession of Hallowell, resembled closely the above, but was not so strong. The different chlorids were determined, and the result was as follows :—

Chlorid of sodium,	17·4000
" " calcium,	9·2050
" " magnesium,	9·4843
Bromids and iodids undetermined.	
	36·0893

From the large amount of earthy chlorids, amounting to one-half their solid contents, it will be evident that these waters are not well adapted to the manufacture of common salt.—See Report for 1847-'48, p. 161.

Sainte Geneviève, on the Batiscan River, affords several mineral springs, which issue from the lower limestones and are strongly saline and neutral; two of these have been quantitatively analyzed. The first is on the land of Olivier Trudel, about a league above the church, and on the banks of the Rivière Veillette. The supply of water is abundant, and bubbles of carburetted hydrogen escape from the spring at short intervals. The water is very strongly but pleasantly saline to the taste, and has a density of 1016·72. It contains abundance of earthy chlorids and carbonates, but no sulphates. The precipitate on boiling was chiefly carbonate of magnesia; that from a litre of the water which had been boiled for an hour consisted of 0·750 gr. of carbonate of magnesia and only 0·012 gr of carbonate of lime, and in evaporating another portion of the water by boiling to one-sixth, the precipitate was found to be purely magnesian, without any carbonate of lime, and only a trace of oxide of iron. It is evident from this, that the dissolved chlorid of magnesium slowly re-dissolves the precipitated carbonate of lime at a temperature of 212° F., a reaction which has indeed long been known, and that the proportions in which the chlorine is divided between the earthy bases in a natural water, cannot be determined from the results of its analysis. This spring is like the last, remarkable for the quantity of iodine which it contains; the unconcentrated water gives the reaction already indicated for the Hallowell saline, and when acidulated with hydrochloric acid, yields with a palladium salt, a precipitate of iodid of palladium after a few hours. 1000 parts of the water were found to contain:

Chlorid of sodium,	17·2671
" " potassium,	·2409
" " calcium,	·6038
" " magnesium,	2·0523
Bromid " sodium,	·0587
Iodid " "	·0133
Carbonate of lime,	·0120
" " magnesia,	·7506
	20·9987

At the ferry, and directly opposite the church of Sainte Geneviève, is another spring, which discharges an abundance of carburetted hydrogen gas. The water is not so bitter to the taste as the last, and is agreeably saline. Although less rich in chlorids than this, it contains the largest amount of iodids yet found in any mineral water of the Province, the quantity of iodine present being equal to $\frac{123}{1000}$ grains of iodid of sodium, or $\frac{140}{1000}$ iodid of potassium to the pound avoirdupois. In the analysis the alkaline chlorids were estimated by the difference between the other salts, which were directly determined, and the total amount of saline matters left on evaporation. 1000 parts gave :

Chlorid of sodium,	11·5094
" " calcium,	·2264
" " magnesium,	·8942
Bromid " sodium,	·0273
Iodid " "	·0183
Carbonate of lime,	·0180
" " magnesia,	·4464
	13·1400

It is to be remarked that all of these waters contain small portions of oxyd of iron, as well as of alumina and silica; the latter elements are never wanting even in neutral waters, although from the minute quantities in which they occur, their presence is generally overlooked. It is sufficient to evaporate to dryness any water with an excess of hydrochloric acid, and to dissolve the residue in water with the addition of a little acid, to obtain a residue of silica. The acid liquid will always yield with ammonia a small precipitate of alumina, generally mingled with oxyd of iron, and containing phosphoric acid. This precipitate moreover rarely fails to give the reactions of manganese.

Berthier.—In the parish of Berthier (Leinster), about a league above the manor, and on the banks of the Bayonne, adjoining the land of Charles Boucher, is a copious saline spring, which discharges bubbles of inflammable gas. The water is cold, clear, and pleasant to the taste; it is neutral,

but contains only a very small portion of earthy chlorids. The quantity of bromine present in this water is considerable, but the amount of iodine is very minute. A partial analysis gave the following results :—

Chlorid of sodium,	8·0454
" " calcium,	·0466
" " magnesium,	·0856
Carbonate of lime,	·0470
" " magnesia,	·8354
Bromids and iodid undetermined.	
	9·0600

Another spring on the bank of the rivulet near the manor, regarded as a chalybeate water, has a feebly ferruginous taste, and deposits a small amount of earthy carbonates mixed with a little oxide of iron; evaporated to one-fiftieth, it contains in solution only traces of chlorids, a small portion of sulphates and a little lime. It can hardly be called a mineral water.

Rawdon.—I have collected the waters from two springs in this township, both of which are alkaline. The first is on the land of Alexander Connolly, lot 27, range 3, where a copious spring of clear, cold, and slightly sulphurous water issues from the banks of the River Blanche; the volume of water discharged may be ten gallons a minute. The channel of the spring is marked by a scanty white deposite. This water is feebly saline and alkaline; 1000 parts of it contain 0·320 of solid matter, consisting of earthy and alkaline carbonates and alkaline chlorids, with small portions of sulphates, borates, and a trace of bromine, but no iodine.

The second spring is on the 25th lot of the same range, on the land of Mr. Thomas Lane. It is strongly saline, and when concentrated, distinctly alkaline to the taste. It contains no sulphates, but traces of baryta and strontia, and gives when evaporated to a small volume, the reactions of boracic acid, bromine and iodine, the latter however very feeble. This water contains 4·96 parts of solid matter in 1000, and has a specific gravity of 1004·47.

Plantagenet.—The water of a newly discovered saline spring said to be from this township, and furnished me by Mr. Peter Macintosh, was neutral and strongly saline, containing 10·16 parts of solid matter in 1000. It yields by boiling abundance of carbonates, and contains but a small proportion of earthy chlorids; the reactions of iodine and bromine are very strong. The water also contains strontia in comparatively large quantity, a little iron, and traces of boracic acid.

Joly.—In the township of Joly there occurs a very interestting spring on the banks of the Ruisseau Magnenat, a branch of the Rivière Souci, about five miles from the mills of Methot at Ste. Croix. The spring furnishes three or four gallons a minute of a water which is sulphurous to the taste and smell, and deposits a white matter along its channel, which exhibits the purple vegetation generally met with in sulphur springs. The temperature of this spring in the evening of the 7th of July was 46° F., the air being 52° F.

This water is not strongly saline, but when concentrated is very alkaline and salt to the taste. It contains besides chlorids, sulphates and carbonates, a considerable proportion of boracic acid, which is made evident by its power of reddening paper colored by turmeric, after being supersaturated with hydrochloric acid. There being no satisfactory process for determining directly boracic acid in such a mixture, the following indirect method was devised:—Having evaporated a portion of the mineral water to dryness, the soluble parts were taken up by distilled water, and carbonate of ammonia added to precipitate a portion of silica. The ammoniacal salt being removed by ebullition, the liquid was digested at a gentle heat with pure recently precipitated carbonate of silver until the whole of the alkaline chlorid was decomposed; the filtrate, holding some oxyd of silver in solution, was evaporated to dryness, and fused in a silver crucible. On re-solution, the reduced silver remained behind. The solution, now containing only alkaline carbonate and borate, with a little sulphate, was again evaporated, and the residue having been fused was submitted to analysis. The carbonic and sulphuric acids, the soda and the potash having been directly determined, the

difference between the sum of these and the original weight of the salt corresponds to the boracic acid. In this process all the errors of analysis fall upon the boracic acid, but no direct method is known for its estimation in such a mixture. The sulphuric acid might be eliminated from the mixed salts by the use of bi-carbonate of baryta, and the process be thus somewhat simplified.

The analysis of 1000 parts of the water gave as follows :—

Chlorid of sodium,	0·3818
" " potassium,	·0067
Sulphate " soda,	·0215
Carbonate and borate of do,	·2301
Carbonate of lime,	·0620
" " magnesia,	·0257
Silica,	·0245
Alumina, (traces)	
	0·7523

The amount of boracic acid estimated by the method just described was found to be equal to 0·0279. The sulphuretted hydrogen was determined by mixing a portion of the water at the spring, with a solution of chlorid of arsenic, and was equivalent to 7.5 cubic centimetres to a litre, being 2.1 cubic inches to an imperial gallon of 277 cubic inches. The amount of solid matter obtained by direct evaporation was 0·740 parts.

I have already alluded to the rareness of mineral springs in the undisturbed portion of the western basin of Canada; it was with the hope of finding some springs in the region north of Toronto which might serve to confirm the observations made in Lower Canada upon the distribution of the different kinds of waters, that I visited last year some springs in the township of Scarborough, which have a local reputation. They occur on the 16th lot of the 14th range, and are two in number, a little distance apart. The waters are clear, and give by boiling a small amount of earthy carbonates; even when evaporated to one-tenth they have no marked taste, and they contain only a little sulphate of lime and traces of chlorids. The water from a well at the Bank of Upper Canada in Toronto has a similar composition, and that of a spring at

Spadina, remarkable for the amount of carbonate of lime which it deposits in the form of calcareous tufa along its channel, contains in solution besides the carbonate, only a trace of chlorids, and no sulphates.

There is a spring in the village of Brompton which is regarded as a mineral water; it has when recent an unpleasant smoky taste, and soon becomes putrid and sulphurous in closed bottles. This water yields by evaporation 0·380 parts of solid matter to 1000, consisting of earthy carbonates with sulphates and chlorids, and a considerable amount of organic matter, which blackens a solution of nitrate of silver. Another copious spring, about half-a-mile below the village of Brampton, on the Etobicoke, was found to deposite a considerable amount of earthy salts in boiling, and when evaporated to one-twentieth to be feebly saline to the taste, containing small quantities of chlorids and sulphates of lime, magnesia and alkalies. It is not probable that any of the six springs just mentioned rise from the underlying Lower Silurian rocks, to the waters of which they bear but little resemblance; they probably owe their feeble saline impregnation to the clays and sands which cover the palæozoic strata of the region.

Waters of the St. Lawrence and Ottawa Rivers.

The plan proposed for supplying the city with water from one of these rivers, having made a knowledge of their chemical composition a matter of considerable interest, I proceeded, agreeable to your desire, to make a careful analysis of their waters. The results, independent of their local value, are important, as showing the composition of two immense rivers which drain so large a portion of the continent.

The time chosen for collecting the waters was in the month of March, before the melting of the snows had commenced; the river waters were then unaffected by the rains and the drainings of the surface, which tend to make their composition variable during the summer season.

The water of the Ottawa was collected on the 9th of last March at the head of the lock at Ste. Anne, where the position

and the rapid current assured me the water of the river free from all local impurities. The river was here unfrozen, owing to the rapidity of the current, and its temperature was found to be 33° F., that of the air being the same.

The water, which was free from all sediment or suspended matter, had a pale amber-yellow color, very distinct in masses of six inches. When heated this color deepens, and by boiling, there separates a bright brown precipitate, which, when the volume of the water is reduced to one-tenth, is seen to consist of small brilliant iridescent scales. These are not gypsum, of which the water does not contain a trace, but consist of carbonates, with silica and organic matter. Meanwhile the water becomes more highly colored, and now exhibits an alkaline reaction with test papers.

The recent water, mingled with hydrochloric acid and a salt of baryta, remains clear for a time, but after an hour a faint turbidness appears, indicating a trace of sulphate. With nitrate of silver and nitric acid, a slight milkiness from the presence of chlorids is perceptible. The amounts of sulphuric acid and chlorine were determined on portions of two or four litres of the water reduced by evaporation to a small volume, and acidulated. The precipitate obtained by the addition of a few drops of nitric acid and nitrate of silver, was scanty and reddish colored. After twelve hours of repose it was collected, dissolved from the filter by ammonia, and the pure chlorid of silver thrown down by a large excess of nitric acid, while the silver-salt of an organic acid remained in the solution.

When the precipitate obtained during the evaporation of the water is boiled with a dilute solution of potash, the organic matter is dissolved, and the alkaline solution assumes a bright brown color, which becomes paler on the addition of acetic acid; acetate of copper produces no precipitate in the liquid thus acidulated, but on adding carbonate of ammonia and heating the mixture, a minute white flocculent precipitate separates, having the characters of crenate of copper. Another portion of the precipitate by evaporation was dissolved in hydrochloric acid, and decolorized by boiling with chlorate of potash; on evaporating the solution a portion of silica sepa-

rated, and the liquid gave with ammonia a colorless precipitate, which was chiefly composed of alumina; re-dissolved in hydrochloric acid however, it gave with a sulphocyanid, evidence of the presence of oxyd of iron, and with molybdate of ammonia an abundant yellow precipitate indicating phosphoric acid. The aluminous precipitate heated on silver foil with caustic potash gave a slight but decided reaction of manganese.

When the concentrated water, with its precipitate, was evaporated to dryness in a platinum capsule with excess of hydrochloric acid, and the residue treated with acidulated water, a large amount of silica was obtained, equal to one-third of all the solid matters present. This silica was white after ignition, and perfectly pure. A portion of the water was evaporated to one-fortieth and filtered; the residue being farther evaporated to one-fourth, deposited on the platinum capsule an opaque film, which was but imperfectly soluble in hydrochloric acid. The concentrated liquid was dark brown and alkaline, reddening turmeric paper; it was now evaporated to dryness, ignited and treated with water. The soluble portion was strongly alkaline to test papers, and perceptibly so to the taste. The residue insoluble in water was treated with strong hydrochloric acid, which dissolved a portion of lime without effervescence, and left a residue of pure silica; the acid solution contained no magnesia.

The dried residue from the evaporation of this water is of a deep brown color; when ignited, the organic matter which it contains burns like tinder, diffusing an agreeable vegetable odour, and leaving a little carbon. The water was not examined for nitrates, but the absence of any deflagration during the ignition of the residue showed, that if present they were in very small amount. The season moreover at which the water was collected (being at the end of a winter of four months of unremitting frost), would not be favorable to the formation of nitrates.

The following numbers are deduced from the means of two or more concordant determinations made upon quantities of two and four litres of the Ottawa, and calculated for ten litres or 10·000 grammes.

Carbonate of lime,	0·2480	grms.
" " magnesia,	·0696	"
Chlorine,	·0076	"
Sulphuric acid,	·0161	"
Silica,	·2060	"
Chlorid of sodium,	·0607	"
" " potassium,	·0293	"
Residue dried at 300° F.,	·6975	"
" ignited,	·5340	"

The amounts of silica remaining dissolved in the water evaporated to one-twentieth and one-thirtieth, were found to be 0·019 and 0·020 for four litres, giving for ten litres a mean of 0·046 grammes of silica thus retained in solution. The amount of lime remaining dissolved in this quantity of the water thus evaporated, was equal to 0·023 of carbonate of lime.

The chlorine and sulphuric acid present in this water are sufficient to neutralize only about one-half of the alkaline bases present; the remaining portion may be regarded as existing in combination either with silica or with the organic acids present, and it is probably in a similar state of combination that a portion of the lime remains dissolved in the evaporated water.

In the following table the lime and the excess of alkalies are however represented as carbonates, and we have for 10,000 parts,

Carbonate of lime,	0·2480
" " magnesia,	·0696
Silica,	·2060
Chlorid of potassium,	·0160
Sulphate of potash,	·0122
" " soda,	·0188
Carbonate of soda,	·0410
Alumina and oxyd of iron,	(traces)
Manganese and phosphoric acid,	"
	0·6116

The water of the St. Lawrence was collected on the 30th of March, on the south side of the Pointe des Cascades, (Vaudreuil.) The rapid current had here left an opening in the ice, from which the water was taken at a distance

of six feet from the shore. It was clear and transparent, and unlike the water of the Ottawa, exhibited no color in vessels several inches in diameter. The recent water gives a considerable precipitate with salts of baryta, and a slight one with nitrate of silver. When boiled it lets fall a white crystalline precipitate, which adheres to the sides of the vessel, unlike the deposit from the Ottawa water. A little yellow flocculent matter appears suspended in the concentrated liquid, which is only slightly colored, and the dried residue contains much less organic matter than that from the last mentioned water. The residue from two litres, when dissolved in hydrochloric acid, sufficed to give distinct reactions of iron and manganese. The ammoniacal precipitate from this solution was in great part soluble in potash, and was alumina. From a second portion of two litres a precipitate of phosphate was obtained by molybdate of ammonia, less abundant however than from the same quantity of the water from the Ottawa. The determinations were made as in the previous analysis, and gave for 10,000 parts,

Carbonate of lime,	0·8033
" " magnesia,	·2537
Chlorine,	·0242
Sulphuric acid,	·0687
Silica,	·3700
Chlorid of potassium,	·0220
" " sodium,	·1280
Residue dried at 300° F.,	1·6780
" ignited,	1·5380

When evaporated to one-fortieth this water still contains in solution a portion of silica and some lime; the silica thus dissolved was found equal to 0·075, and the lime to 0·050 of carbonate of lime for 10,000 parts. The proportions of sulphuric acid and chlorine are much larger than in the Ottawa water, but were found not quite sufficient to saturate the whole of the alkaline bases present. The small portion of lime is probably held in solution by the concentrated water in the form of silicate, which, as is well known, possesses a certain degree of solubility, while from the insolubility of the

silicate of magnesia, this base is completely separated during the evaporation.

I subjoin the calculated results for 10,000 parts of the St. Lawrence water, the lime and magnesia and the slight excess of alkalies being represented as carbonates.

Carbonate of lime,	0·8083
" " magnesia,	·2537
Silica,	·3700
Chlorid of potassium,	·0220
" " sodium,	·0225
Sulphate of soda,	·1229
Carbonate "	·0061
Alumina, phosphoric acid,	(traces.)
Oxyds of iron and manganese,	"
	1·6055

The ignition of the dried residue expels a portion of carbonic acid from the earthy carbonates, and hence the calculated results exceed the weight of the residue, besides which considerable portions of the lime and magnesia are combined with silica, and not with carbonic acid as in the calculated table.

The comparison of the water of these two rivers shows the following differences:—The water of the Ottawa, containing but little more than one-third as much solid matter as the St. Lawrence, is impregnated with a much larger portion of organic matter derived from the decomposition of vegetable remains, and a large amount of alkalies uncombined with chlorine or sulphuric acid. Of the alkalies determined as chlorids, the chlorid of potassium in the Ottawa water forms 32 per cent. and in that of the St. Lawrence only 16 per cent., while in the former the silica equals 34 per cent., and in the latter 23 per cent. of the mineral matters. The Ottawa drains a region of crystalline rocks, and receives from these by far the greater part of its waters; hence the salts of potash liberated by the decomposition of these rocks are in large proportion. The extensive vegetable decomposition, evidenced by the organic matters dissolved in the water, will also have contributed a portion of potash. It will be recollected that the proportions of potash salts in the chlorids of sea-water and

saline waters generally, does not equal more than two or three per cent. As to the St. Lawrence, although the basin of Lake Superior in which the river takes its origin is surrounded by ancient sandstones, and by crystalline rocks, it afterwards flows through lakes whose basins are composed of palæozoic strata which abound in limestones rich in gypsum and salt, and these rocks have given the waters of this river that predominance of soda, chlorine and sulphuric acid which distinguishes it from the Ottawa. It is an interesting geographical feature of these two rivers that they each pass through a series of great lakes, in which the waters are enabled to deposit their suspended impurities, and thus are rendered remarkably clear and transparent.

The presence of large amounts of silica in river waters is a tact only recently established, by the analyses by H. Ste. Claire Deville of the rivers of France.* The silica of waters had generally been entirely or in great part overlooked, or had, as he suggests, from the mode of analysis adopted, been confounded with gypsum. The importance in an agricultural point of view of such an amount of dissolved silica, where river waters serve for the irrigation of the soil, is very great, and geologically it is not less significant, as it marks a decomposition of the silicious rocks by the action of water holding in solution carbonic acid, and the organic acids arising from the decay of vegetable matter. These acids combining with the bases of the native silicates, liberate the silica in a soluble form. In fact silica is never wanting in natural waters, whether neutral or alkaline, although proportionately much greater in those surface waters which are but slightly charged with mineral ingredients. The alumina, whose presence is not less constant, although in smaller quantity, equally belongs to the soluble constituents of the water. The quantity of silica annually carried to the sea in solution by the St. Lawrence and similar rivers, is very great, and doubtless plays an important part in the silicification of organic remains, and in the formation of silicious deposits, both directly and through the intervention of silicious infusorial animals.

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* *Annales de Chimie et de Physique*, 1848, vol. xxiii., p. 32.

As regards the question of a supply of water for the city of Montreal, it is to be remarked that the composition of these waters will be subject to considerable changes with the different seasons. The waters from the melting of the snows and the autumnal rains, will give to the river a character somewhat different from that presented after the long droughts of summer, or after several months of continued frost, when we may suppose that the water will contain the largest amount of soluble matters.

The waters of the St. Lawrence meeting those of the Ottawa below Vaudreuil, the two flow side by side, and may, as is well known, be distinguished by their difference of color. The clear greenish-blue of the larger river contrasts strongly with the amber-brown color of its tributary. The agitation of the current however gradually mingles the two streams, and even the brown water along the front of the island of Montreal is already mixed with a considerable portion of the St. Lawrence water, as will be evident from the analyses given below. As but a portion of the Ottawa enters the channel of the St. Lawrence at the head of the island, and as the volume of the former river is very variable, it happens that the proportions of the mixture at a given point in front of the island are subject to considerable changes. At the close of the summer and winter seasons the waters of the Ottawa are comparatively low, and then it may be observed that the water supplied by the City Water Works is but slightly colored, the water of the St. Lawrence predominating, while during the spring floods its deep color shows the larger proportion of Ottawa water. It hence follows that the purity of our supply of water is in an inverse ratio with its color, and that in obtaining an uncolored water we exchange a small proportion of organic matter for a much larger amount of calcareous salts.

I subjoin the results of some analyses of the mixed waters taken in front of the island of Montreal. The first (I.) is from a specimen collected on the 9th of March, the same day as that of the Ottawa, whose analysis is given above. It was taken at Lower Lachine, about thirty feet from the shore, and

opposite the entrance to the new aqueduct, Mr. T. C. Keefer, the engineer of the work, accompanying me and indicating the locality. The second (II.) was taken from the well of the present Water Works, immediately after it had been pumped up from the river on the 15th of March; the pale yellow color of both of these waters indicated that the St. Lawrence predominated in the mixture. The third column (III.) contains some determinations made in the month of April, 1850, when the spring floods had evidently augmented the volume of the Ottawa. The water was collected from the supply-pipe in the laboratory of the Survey. They are calculated as in the previous analysis for 10,000 parts,

	I.	II.	
Carbonate of lime,	·6440	·7400	·4228
" " magnesia,	·1970	·2160	·0989
Silica,	·3250	·3450	....
Chlorine,	·0183	·0296	·0296
Sulphuric acid,	·0487	·0498	·0447
Residue dried at 300° F.,	1·4150	1·5600	....
" ignited,	1·2020	1·3750	....

The composition of II. shows that opposite the city, where the water is taken for our present supply, there is, as might be expected, a greater mixture of the St. Lawrence water than at Lower Lachine. The amount of chlorine which it contains is moreover worthy of especial notice, it being greater than in the pure water of the St. Lawrence, which yields ·0243 of chlorine (the Ottawa water containing only ·0076 of this element.) The result obtained in April 1850 shows a similar excess, and another determination which I made on the water drawn on the 11th of last April from the supply-pipe in my laboratory gave ·0284 of chlorine. This constant excess of chlorine in the water raised from the river in front of the city, indicates a local source of this element, probably due to the drainage of the town. It is known that the springs which issue from the limestones of the island contain a considerable portion of saline matter, and to this, carried by the sewerage near to the mouth of the supply-pipe of the water works, we may attribute the predominance of chlorids in the water.

Limestones and Dolomites.

The following are some analysis of dolomites, and limestones more or less magnesian, from the Laurentian rocks. The specimens were collected by Mr. Murray in his examination of last year, and their position in the stratification will be found described in his report.

I. This is a dolomite from the fourth lot of the tenth range of Loughborough; it is made up of large cleaveable grains, weathers reddish, and contains disseminated particles of a matter which is probably serpentine, and which when the rock is dissolved in hydrochloric acid, remains behind intermingled with quartz. The analysis gave :—

Carbonate of lime (by difference),	55·79
" " magnesia,	37·11
Insoluble, quartz, etc.,	7·10
Oxyd of iron and phosphates,	(traces.)
	100·00

II. This specimen is from the sixth lot of the tenth range of the township of Loughborough; it is a coarsely crystalline limestone, but very coherent, snow-white, vitreous, and translucent in an unusual degree. It holds small grains of disseminated tremolite, quartz, sometimes rose-colored, bluish and greenish apatite, and yellowish-brown mica, but all in very small quantities. Its analysis gave 4·00 per cent. of insoluble matters, and 7·50 per cent. of carbonate of magnesia, with a trace only of oxyd of iron. This magnesian limestone is not however homogeneous in its composition, as the following experiment shows; a portion in coarse powder was digested in dilute acetic acid; this was renewed, and the action continued with the aid of heat, so long as any effervescence was apparent. The white granular residue after being washed and dried, was not attacked in the cold by diluted hydrochloric acid, but dissolved by heat with effervescence, leaving a residue of quartz, tremolite and mica. The portion thus dissolved was found to consist of carbonate of lime 63·30, carbonate of magnesia 36·70, approaching to a pure dolomite

by its composition, while the large portion dissolved by acetic acid contained only 3·65 per cent of magnesian carbonate. The rock is thus evidently a mixture of dolomite with carbonate of lime ; dolomite itself is not altogether insoluble in acetic acid, and hence a portion of magnesia is found in the acetic solution.

III. This rock, from the first lot of the sixth concession of Sheffield, is pure white in color, and coarsely crystalline, exhibiting upon the cleavage faces diagonal striæ. The density of selected fragments was found to be 7·863—7·864. It is a nearly pure dolomite. Analysis gave :—

Carbonate of lime,	52·57
" " magnesia,	45·97
Peroxyd of iron,	·24
Quartz and mica,	·60
	99·38

IV. This dolomite is from the thirteenth lot of the eighth concession of Madoc. It is grayish-white in color, fine-grained, almost compact, and has a conchoidal fracture. Small veins of quartz intersect the rock, which has a density of 2·849. Analysis gave :—

Carbonate of lime,	46·47
" " magnesia,	40·17
Peroxyd of iron	1·24
Quartz,	12·16
	100·04

V. This is a fine-grained, grayish-white, silicious magnesian limestone from the fourth lot of the fifth concession of Madoc ; it has a density of 2·757, and contains a portion of carbonate of iron. Its analysis gave :—

Carbonate of lime,	51·90
" " magnesia,	11·39
" " iron,	4·71
Quartz,	32·00
	100·00

VI. This is a reddish granular dolomite from the village of Madoc, having a density of 2·834. Its analysis gave :—

Carbonate of lime,	57·37
" " magnesia,	34·66
Peroxyd of iron,	1·32
Quartz,	7·10
	100·45

Fossil Shells, &c.

In the Report of Progress for 1852-53, p. 173, it was mentioned that the fossil shells of the *Lingula Mantelli* (nov. sp.,) which occur in a sandstone belonging to the Chazy limestone, at the Lac des Allumettes, were found to be composed in great part of phosphate of lime, thus explaining the origin of the phosphatic coprolites which occur in the same rock at that place, as well as at Grenville, Hawkesbury, and many other localities. (See Report for 1851-52, pp. 106-111.) Having found that the *Lingula quadrata* from the Trenton limestone has a similar composition, I proceeded at your desire to examine the *Lingula prima*, and *L. antiqua* from the Potsdam sandstone, both of which were found to consist in great part of phosphate of lime. A recent species, *L. ovalis*, from the Sandwich Islands, was then examined, and found to have a similar composition. The green epidermis of the shell, which swells up like horn when heated, leaves by incineration a white residue of phosphate of lime. The whole shell left after calcination 61·0 per cent. of earthy matter, whose analysis gave :—

Phosphate of lime,	85·79
Carbonate " "	11·75
Magnesia,	2·80
	100·34

This is very nearly the composition of calcined human bones.

The external characters of the fossil *Lingulæ* are unlike those of most other fossil shells; they are more or less dark-brown in colour, brilliant, almost opaque, and not at all crystalline. The same characters are observed in the fossil species of the closely allied genus *Orbicula,* and on examining two undescribed species of this genus from the Trenton limestone, and from the Upper Silurian, as well as a recent species, *O. lamellosa* from Callao, they were all found to consist chiefly of phosphate of lime. Similar physical characters being observed in the shells of the genus *Conularia*, a fragment of *C. trentonensis* was examined, and found to have the same composition as *Lingula* and *Orbicula.* All of these dissolve with very slight effervescence in hydrochloric acid, and the solution gives with ammonia a copious precipitate of phosphate of lime, soluble in acetic acid. The solution affords with molybdate of ammonia, an abundant yellow precipitate of the characteristic molybdo-phosphate.

Several other fossil shells were examined for the sake of comparison ; among them *Atrypa extans*, *Leptena alternata* and *Orthis pectenella* from the Trenton limestone, *O. erratica* from the Hudson River Group, and *Chonetes lata* (?) from the Upper Silurian, besides a species of *Cythere* from the Trenton. The external characters of all these were very different from *Lingula* and *Orbicula;* they were lighter colored, more translucent, and granular in texture, and were found to consist of carbonate of lime, with only such traces of phosphate as are generally found in calcareous shells.

Assays of Galena and Gold.

The galena from Lansdowne was assayed by fusion with salt of tartar and nitre, and gave 81·0 p. c. of metallic lead, which left on cupellation but a very minute proportion of silver. The result of three closely agreeing assays gave only one and a-half ounces of silver to the ton of ore. The galena from Bedford, treated in the same manner, gave one and seven-eighth ounces of silver, and that from Ramsay two and a-half ounces of silver to the ton.

The quantity of the precious metal in the above ores is so small that it can scarcely be said to enhance the value of the lead; but the case is different with the lead ore from Meredith's location on Lake Superior. The galena here occurs with variegated copper ore, in calcareous spar with laumontite. A portion freed from copper was reduced by fusion with borax, salt of tartar and metallic iron, and gave by cupellation a quantity of silver equal to thirty and a-quarter ounces of silver to the ton of metallic lead. In another assay a portion of the galena from this locality, mixed with some copper ore, was fused with salt of tartar and nitre, and the reduced lead, with some adhering copper, gave at the rate of forty-three ounces of silver to the ton of metal; but in this assay, a portion of the lead having been oxydized by the nitre, the determination is above the truth, and is only valuable as confirming the highly argentiferous character of the galena.

A vein which occurs at the rapids of the Chaudière, in the parish of St. François, (Beauce) contains in a gangue of quartz, galena, blende, arsenical sulphuret of iron often well crystallized, besides cubic and magnetic iron pyrites, and native gold in minute grains. A portion of galena from the assorted and washed ore, still containing a mixture of blende and pyrites, gave by assay 69·0 p. c. of lead, and thirty-two ounces of silver to the ton (2240 pounds) of ore. Another sample of the galena more carefully dressed, gave at the rate of thirty-seven ounces of silver. The button of silver obtained by cupellation from this lead, contained a small but appreciable quantity of gold. The assay of a second portion of the sample of ore which gave 69·0 per cent. of lead, afforded by cupellation a quantity of silver equal to not less than 256 ounces of silver to the ton. This amount of silver was probably due to the presence of a fragment of some silver ore, perhaps a sulphuret, in the mixture of crushed and dressed galena. These assays were each made upon 500 grains. 1000 grains of the pyrites from this vein, mixed with a little blende, galena, and arsenical ore, were roasted, and then being mingled with litharge, borax and salt of tartar, were fused with the addition of fragments of iron, and a button of lead obtained, which left by cupellation a

globule of 0·15 grains of an alloy of gold and silver. 700 grains of the impure blende were then roasted and treated in a similar manner, and gave by cupellation 0·19 grains of a pale yellow alloy; the buttons thus obtained contained a large proportion of gold, especially that from the blende, which retained its form and assumed a deep yellow color, when, after having been beaten out, it was boiled with nitric acid, which dissolved a portion of silver.

Gold.—A quantity of gold dust, from the washing of the sands of the Rivière du Loup, was submitted to amalgamation, and left one-third of its weight of black ferruginous sand, of which eighteen per cent. were separable by the magnet; the non-magnetic portion was dissolved by the successive action of hydrochloric acid and bisulphate of potash, leaving 4·8 per cent. of silicious residue. The solutions contained iron and chromium, and gave by prolonged ebullition, 23·15 p. c. of by titanic acid. The mingled solutions afforded no trace of tin hydrosulphuric acid, and were examined without success for uranium, cerium and the rarer bases. The frequent presence of tin ore in the auriferous gravel of different countries, should encourage us to search for that valuable metal in our own gold-bearing region. Samarskite, monazite, and other minerals containing uranium, cerium, etc., are also sometimes met met with in this association, and hence these bases were sought for in the above examination.

The gold obtained by the distillation of the amalgam, lost 4·27 p. c. by fusion with borax, and the assay of the resulting ingot gave 12·87 p. c. of silver. Thirty grammes of this alloy were dissolved in aqua regia, and the solution examined without success for copper and palladium; a minute portion of platinum, amounting to ·0012 p. c., was however obtained. The remaining portion of the alloy was pure gold.

I have the honor to be,

Sir,

Your most obedient servant,

T. STERRY HUNT.

REPORT

FOR THE YEAR 1854,

OF

T. STERRY HUNT, ESQ., CHEMIST AND MINERALOGIST TO THE GEOLOGICAL SURVEY,

ADDRESSED TO

WILLIAM EDMOND LOGAN, ESQ., F.R.S., DIRECTOR OF THE GEOLOGICAL SURVEY OF CANADA.

MONTREAL, 1*st* *April*, 1855.

SIR,

In the following Report I have the honor to submit to you the commencement of a series of investigations of the stratified crystalline or metamorphic rocks of the country, undertaken in the hope that a careful comparative study of their composition, in connection with that of the unaltered sedimentary strata, may lead to a clear understanding of the nature of that metamorphic process whose results are so conspicuous in our Canadian Geology.

In my Report for 1853 I had occasion to call your attention to the existence of the species known as Labrador felspar, among the specimens brought by you from the townships of Morin and Abercrombie, and to express the hope that farther researches would enable us to determine more accurately than had yet been done, the geological relations of this mineral species, and the rocks of which it forms the principal part. The investigations which I have made in connection with yourself in the county of Terrebonne and Montmorenci, and

subsequently my own examinations in the county of Leinster, have justified the expectation, and furnished a quantity of materials which have been partially examined during the past winter.

The rocks about to be described belong to the crystalline strata of the Laurentide mountains, and occur, as far as yet observed, in close association with the crystalline limestones, which alternate with the gneissoid and quartzose rocks of the formation. They are composed chiefly of felspar, with small portions of black mica, green pyroxene, and occasionally epidote, garnet and quartz; portions of hypersthene are also frequently present, and hence the New York Geologists have designated these essentially felspathic strata, by the name of *hypersthene rock*. In addition to the minerals just mentioned we may add ilmenite or titaniferous iron, which occurs sometimes in large masses, and at other times in small disseminated grains, which like the hypersthene, appear to mark the places of stratification. If to these we add small portions of iron pyrites, and a little disseminated carbonate of lime, we shall have the mineralogy of these rocks so far as yet known.

The texture of these felspar rocks is varied; sometimes the mass is a confusedly crystalline aggregate, exhibiting cleavage surfaces three or four lines in diameter, with a fine grained, somewhat calcareous paste in the interstices. Sometimes the whole rock is uniformly granular, while more frequently a granular base holds at intervals, cleavable masses of felspar, often several inches in diameter. The colours of these rocks vary from grayish and bluish-white, to lavender and violet-blue; flesh-red, greenish and brownish tints are also met with: the colours are rarely brilliant. These felspars seldom occur in distinct crystals, but their cleavage is triclinic, a fact which taken in connection with the densities, varying from 2·66 to 2·73, shows them to belong to the group of which albite and anorthite may be taken as the representatives. The bluish cleavable varieties often exhibit the opalescence of labradorite, to which species American mineralogists have hitherto referred them; but with the exception of a few analyses by myself, we have had as yet no published chemical

examinations of any of these felspars. My investigations show that while all of them are felspars with a base of lime and soda, the composition varies very much, being sometimes that of labradorite, andesine, or intermediate varieties, and at other times approaching to that of anorthite. The results of these investigations, so far as yet completed, I have now the honour to submit to you, as the first part of the history of this felspathic formation.

One of the most interesting localities of these felspathic rocks is in the parish of Château Richer (Montmorenci), where they cover a breadth of two or three miles across the strike, bounded by crystalline limestone on one side, and a quartzo-felspathic rock on the other, and rising into small hills. In this region there occur several varieties of the rock, but the most interesting is one made up of a fine granular base, greenish or grayish-white in colour, holding masses of a reddish cleavable felspar, which are sometimes from one-tenth to one-half an inch in diameter, but often take the form of large imperfect crystals, frequently twelve inches long and four or five inches wide. These dimensions correspond to the faces M and T, while the face P, characterized by its perfect cleavage, is from half-an-inch to two inches broad. Twin crystals sometimes occur, having a composition parallel to M.

Hypersthene is met with throughout the rock in flattened masses, which, although variable and irregular in their distribution, exhibit a general parallelism; they are occasionally four or five inches in breadth, by an inch or more in thickness, and are separated from the granular felspathic rock by a thin film of brownish-black mica. Titaniferous iron ore is also found in the rock in grains and lenticular masses, occasionally an inch or two in thickness; these occur in the granular base, and generally near the hypersthene, but grains of the ore are occasionally found in the crystalline felspar. Quartz in small grains is imbedded in the titaniferous iron ore, but was not observed elsewhere in the rock, nor have any other minerals than these been detected. In the specimens of the rock which I selected on the spot for examination, the crystalline felspar constitutes from one-half to seven-eighths, while

the hypersthene does not equal more than two-hundredths, and the titaniferous iron more than one-hundredth of the mass; the amounts of the quartz and mica are insignificant. In other portions of the rock, however, the proportion of the ore may equal five-hundredths, and in some parts the amount of the hypersthene is nearly as great. By the action of the weather the surface of the rock becomes of a dull opaque white; the cleavable masses of felspar are, however, less affected than the granular portion, and by their obscure reddish colour are distinctly visible on the weathered surfaces; this change extends but a very little distance into the rock. The colour of the iron ore of course remains unaltered, but the dark brown hypersthene becomes lighter, and inclines to pinchbeck brown.

This felspar is triclinic in cleavage; the angle of P : M= about 80° 30′; cleavage with P, perfect; with the other planes distinct; P is often delicately striated, and sometimes curved; hardness 6·0, and density 2·667 to 2·674. Lustre vitreous, sometimes pearly on P; colour flesh-red, passing into reddish, greenish and greyish-brown; the surfaces are sometimes clouded with these different tints, but the red predominates.

The following analyses were made of three different specimens, which were carefully selected, pulverized, and then dried at 212° F. The earthy ingredients were determined after fusion with carbonate of soda, and the alkalies by the method of Dr. J. Lawrence Smith, which consists in igniting for thirty minutes the finely levigated mineral with five or six parts of carbonate of lime, and three-fourths its own weight of sal-ammoniac. The agglutinated mass slakes by the action of water, and yields to that liquid its alkalies in the form of chlorids, mixed with chlorid of calcium. A second ignition of the undissolved residue with two-thirds of the first amount of sal-ammoniac, ensures the separation of the last portions of alkali. These processes. were adopted in all the analysis of felspars here given :—

	I.	II.	III.
Silica,	59·55	59·85	59.80
Alumina,	25·62	25·55	25·39

Peroxyd of iron,	·75	·65	·60
Lime,	7·73	6·94	7·78
Magnesia, (traces.)		·11	·11
Potash,	·96	·96	1·00
Soda,	5·09	5·09	5·14
Loss by ignition,	·45	·30	·00
	100·15	99·45	99·82

In a fourth specimen the quantity of lime was found equal to 7·89 p. c. The composition of this felspar is very nearly that of andesine, which according to Abich, consists of silica, 59·60; alumina, 24,18; peroxyd of iron, 1·58; lime, 5·77; magnesia, 1·08; potash, 1·08; soda, 6·53=99·92.

The greenish base of this rock is in general finely granular, and strongly coherent; the grains possess the cleavage, lustre and hardness of felspar, and the density of carefully chosen fragments, was from 2·665 to 2·668. The greenish-white of the powder is changed to fawn colour by ignition. When pulverized and digested with acetic acid, the mineral loses two or three thousandths of carbonate of lime, with traces of magnesia, alumina, and oxyd of iron. A portion which had been thus treated and carefully dried, gave the following results.

	IV.
Silica,	58·50
Alumina,	25·80
Peroxyd of iron,	1·00
Lime,	8·06
Magnesia,	·20
Potash,	1.16
Soda,	5·45
Loss by ignition,	·40
	100·57

It is therefore a felspar, differing but little from the crystalline andesine in its composition.

The hypersthene occurs in foliated masses with curved surfaces. Besides the basal cleavage thus exhibited, it cleaves readily with the sides and the longer diagonal of an oblique prism of 87°. The hardnesss of the mineral is 6·0, and its density from 3.409 to 3·417. Lustre vitreous, sub-metallic;

colour blackish-brown, in thin laminæ yellowish-brown; streak and powder ash-gray, the powder turning reddish-gray on ignition. Sub-translucent, brittle; fracture, uneven. The fragments which had served to determine the density, still contained between their laminæ flakes of felspathic matter, which were as far as possible removed in breaking up the hypersthene for analysis. The results of two analyses by fusion with carbonate of soda were as follows:

	V.	VI.
Silica,....................................	51·85	51·35
Alumina,....................................	3·90	3·70
Peroxyd of iron,....................................	20·20	20·56
Lime,....................................	1·60	1·68
Magnesia,....................................	21·91	22·59
Manganese,........................	(traces)	
Loss on ignition,....................................	·20	·10
	99·66	99.98

It is almost identical in composition with the hypersthene from Labrador, analysed by Damour.

The accompanying ilmenite was more or less interpenetrated with felspar and quartz, which could not easily be separated. Its hardness was 6·0 and the density of selected fragments from 4·65 to 4·68. Colour and streak iron-black; lustre sub-metallic; not attracted by the magnet. When decomposed by fusion with bisulphate of potash it gave.

	VII.
Titanic acid,..	39.86
Peroxyd of iron,..	56·64
Magnesia,..	1·44
Insoluble, quartz, &c.,..	4·90
	102·84

A large portion of the iron is to be regarded as existing in the form of protoxyd.

Another variety of felspar rock from Château Richer is is pale greenish or bluish-gray, with occasional reddish grains, and is finely granular. The lustre is vitreous upon the cleavages, but waxy elsewhere. The only foreign mineral

observed in the rock was brownish-black mica in small scattered patches. The density of the greenish-gray portion was 2·681, and its analysis gave as follows:

	VIII.
Silica,	55·80
Alumina,	26·90
Peroxyd of iron,	1·53
Lime,	9·01
Magnesia,	·27
Potash,	·86
Soda,	4.77
Loss by ignition,	·45
	99·59

In the parish of Château Richer and its vicinity there are found boulders of a well marked variety of the felspar rock, which has not been met with *in situ.* The base is a coarsely granular felspar, of a light reddish-gray colour and vitreous lustre, exhibiting everywhere distinct cleavages, and holding imbedded small brilliant grains of ilmenite, surrounded with thin films of brownish mica. The imbedded crystals of felspar are numerous, and often three or four inches in length and breadth, by an inch in thickness. The faces of the perfect cleavage are beautifully striated, and the smaller crystals, which are often slender and well defined, are sometimes curved. Hardness 6; density 2·680 to 2·692; lustre vitreous; colour pale lavender-blue, with pearly opalescence; semi-transparent; fracture conchoidal.

Analysis IX. is of a cleavable fragment from a boulder of this variety found at Château Richer, and X. and XI. are from a similar and larger mass in the neighbouring parish of St. Joachim.

	IX.	X.	XI.
Silica,	57·20	57·55	57·35
Alumina,	26·40	27·10	27·30
Peroxyd of iron,	·40		
Lime,	8·34	8·73	
Potash,	·84	·79	
Soda,	5·83	5·38	
Loss by ignition,	·65	·20	·25
	99·66	99·75	

The district of Montreal also affords extensive exposures of these same felspar rocks, associated with crystalline limestone, in the counties of Leinster and Terrebonne. In the townships of Rawdon and Chertsey, they are often fine-grained and homogeneous, and constitute an exceedingly tough rock, with an uneven sub-conchoidal fracture, and a feebly vitreous lustre; this variety is bluish or grayish-white in colour, somewhat translucent, and exhibits here and there the cleavage of grains of felspar. Great masses of this rock are almost free from foreign minerals, while other portions abound in a green granular pyroxene, arranged in thin, interrupted, parallel layers, with ilmenite. These layers of pyroxene are seldom more than four or five lines in thickness, and occur an inch or two apart, while the layers of the ilmenite are still thinner and often enclosed in those of the pyroxene, along the limits of which deep-red grains of garnet are occasionally seen. These different minerals appear in relief on the white weathered surface of the rock, and give a picture of its stratified structure, which is however not less apparent on the surfaces of recent fracture. Small rounded bluish masses of cleavable felspar are frequently disseminated in the same planes as the other minerals. In some instances the pyroxene appears to graduate into and to be replaced by foliated hypersthene.

The compact felspars of this region resemble some specimens of the so-called saussurite, and many portions of these rocks would constitue varieties of euphotide.

A fragment of a homogenous massive felspar from Rawdon had a density of 2·691. It was bluish-white, granular, and translucent, and gave by analysis:

	XII.
Silica,	54·45
Alumina,	28·05
Peroxyd of iron,	·45
Lime,	9·68
Potash,	1·06
Soda,	6·25
by ignition,	·55
	100·49

This is essentially the composition of labradorite. See my Reports for 1851, p. 40, and for 1853, p. 167, for analyses of two opalescent felspars, containing 54·20 and 54·70 of silica, and 11·25 and 11·42 of lime, with less alkali than the felspar of Rawdon. In the first mentioned Report, page 166, will be found an examination of Thompson's bytownite, which occurs in boulders on the Ottawa, and is, as I then described it, nothing more than a granular variety of the felspathic rocks under description. It gave 47·40 of silica, and 14·24 of lime, with 2·00 of matter volatile by ignition; its density was 2.732.

Another variety of this rock, from a boulder found at Hunterstown, was more coarsely crystalline than the bytownite, and contained imbedded a large cleavable mass of felspar, which was translucent, of a pale sea-green colour, and possessed a density of 2·695—2·703. Its analysis gave me:

	XIII.	
Silica,	49.10	48·90
Alumina,	26·80	
Peroxyd of iron,	·80	
Lime,	14·67	15·40
Magnesia,	(traces)	
Alkalies by difference,	7·33	
Loss by ignition,	1·30	
	100·00	

At Lachute, on the Rivière du Nord, there is a felspar rock which you have described as associated with crystalline limestone, and which consists of a greenish granular base, holding cleavable masses of a beautiful felspar, approaching andesine in its composition. Its lustre is vitreous, and the face, as in all these felspars, is finely striated; density 2·687; colour lavender-blue, passing into sapphire-blue; semi-transparent. Its analysis gave:

	XIV.
Silica,	58·15
Alumina,	26·09
Peroxyd of iron,	·50
Lime,	7·78
Magnesia,	·16
Potash,	1·21
Soda,	5·55
Loss on ignition,	·45
	99·89

This felspar resembles closely in its composition the rose coloured crystals from the red antique porphyry of Egypt, analysed by Delesse. He obtained, silica, 58·92; alumina, 22·49; peroxyd of iron, 0·75; oxyd of manganese, 0·60; lime, 5·53; magnesia, 1·87; potash, 0·93; soda, 6·93; volatile matters, 1·64=99·66. After comparing this felspar with certain varieties of andesine and oligoclase, this learned author remarks "it is much more important to know the composition of the felspars which form the base of rocks, than to discuss the names to be applied to these felspars. I have already had occasion to remark that we have hitherto attached too much importance to the varieties of the felspars of the sixth crystalline system, and that nature has not always been limited by the divisions established among them by chemists and geologists; the same rock sometimes containing several varieties of these felspars."—*Delesse, Bulletin de la Société Géologique de France*, 2e série, tome vii., p. 524.

Delesse further remarks in this connection, that "the paste and crystals of those porphyries which are without quartz, contain nearly equal proportions of silica. In the paste, however, the silica generally predominates slightly, while the proportions of alumina, alkalies, and lime are somewhat less, and the amounts of magnesia and oxyd of iron are larger. These relations between the paste of porphyries and their contained crystals of triclinic felspar, are of general application for the porphyries of every age and colour." This observation finds its application to a certain extent in the case of the rocks under consideration, which like the porphyries in question are destitute of quartz, and often consist of crystals of triclinic felspar imbedded in a felspathic paste, which differs but little from the crystals in composition. This paste is however generally so crystalline in its texture, that these rocks, although often porphyritic in structure, are rarely entitled to the name of porphyries.

We find in the rocks which have been the subject of these examinations, a series of triclinic felspars in which the amount of silica varies from 47·40 to 59·80 per cent., and that of the lime from 7·73 to 14·24 per cent., the amount of the alkalies

as a general rule decreasing, as that of the lime augments. These results only serve to confirm the opinion expressed by Delesse, and to show that there are no defined limits for these species which, like vosgite, labradorite, andesine, and oligoclase, have been created between albite on the one hand, and anorthite on the other. I therefore some time since proposed to regard all the intermediate felspars as mixtures of these two species, which being homœomorphous, may crystallize together in indefinite proportions. The admitted formulas of albite and anorthite, when multiplied, become as follows: (Silica being SiO, and Al^2O^3=3alO.)

	Equiv. wt.		Density.		Eq. vol.
Albite,.......$(Si^{48}al^{12}Na^4)O^{64}$....	1054·4	÷	2·62	=	402·4
Anorthite,....$(Si^{32}al^{24}Ca^8)O^{64}$....	1118·4	÷	2·72	=	405·0

Albite is then a soda felspar, and anorthite a felspar with a lime base, the two crystallizing in similar forms, and having the same atomic volume; the composition and densities of the intermediate felspars are such as permit us to regard them for the most part as mixture of these two species. There may however be a lime-albite and a soda-anorthite, for some albites contain from 1·0 to 2·5 per cent. of lime, and there are anorthites which yield from three to four per cent. of alkalies. In like manner the constant association of a small amount of potash with the soda of these felspars, lead us to infer the admixture of a potash-albite, which would be a triclinic orthoclase. Equally significant is the presence of portions of magnesia and potash in many varieties of anorthite. The difficulties presented by the varying composition of these felspars are obviated by admitting such mixtures of species as constantly take in the crystallization of homœomorphous salts from mixed solutions, and this consideration should never be lost sight of in the study of mineralogical chemistry.

Silurian Rocks.

In the Report for 1851-52, I had occasion to call your attention to the composition of some of the sedimentary rocks

of the Hudson River group, and to the local metamorphism which they had undergone in the vicinity of intrusive trap rocks at St. Nicolas, resulting in the production of minerals wholly unlike those produced by the wide-spread metamorphism which has modified the Silurian strata through a large part of the eastern basin. You have appreciated the importance of carefully conducted chemical examinations as a means of arriving at correct ideas of the nature of this metamorphism, and in continuation of my investigations, I have now to present some additional analyses of rocks from the Silurian series.

In your Report for 1852-53, while describing the roofing slate of Kingsey, you have given the results of some analyses, in which I have compared this slate with similar ones from Wales and from France. I have to add to these, the examination of another roofing slate from Westbury, which unlike that of Kingsey, belongs to the Upper Silurian division. It has a greenish-blue color, a silky lustre on the cleavage sufaces, is translucent on the edges, and has the characters of an excellent roofing slate. Its density is 2·771, and it gave by analysis :—

Silica,	65·85
Alumina,	16·65
Protoxyd of iron,	5·31
Lime,	·59
Magnesia,	2·95
Potash,	3·74
Soda,	1·31
Manganese,	(traces)
Water,	3·10
	99·50

The shining lustre and talcose aspect of many of the altered slates of this region, do not depend upon the presence of talc or other magnesian minerals, as is evident from the analysis of one of these slates from Ste. Marie, (Beauce.) The red and green slates of this locality undoubtedly belong to the Sillery group; they are very much intersected by veins of quartz, and would be described as having a highly chloritic or rather talcose character. The red beds have a purplish or lilac color,

and their cleavage surfaces are occasionally spotted with films and scales of a greenish mineral, resembling chlorite in appearance. Both the red and green beds are very soft and fissile, exfoliating by the action of the weather, and even becoming converted into a paste, which is very unctuous to the touch, and has a silvery glimmering lustre. These slates are well seen on the second concession of Ste. Marie, where they have been quarried in making explorations for copper pyrites, which occurs there in small quantities. A portion of the pale reddish, highly unctuous material, was freed from quartzose particles by eleutriation, and after being dried at 212° F., gave the following results on analysis:—

Silica,	66·70
Alumina,	16·20
Peroxyd of iron,	6·90
Lime,	·67
Magnesia,	2·75
Alkalies (by difference),	3·68
Water,	3·10
	100·00

From the color of the mineral it is probable that the iron exists in the state of peroxyd; apart from this difference the composition of the slate of Ste. Marie is almost identical with that of Westbury just described. It would be regarded by most observers as a highly talcose slate, but is almost destitute of magnesia, of which talc contains 33·0 p. c., and chlorite about the same proportion. It is probable that the talcoïd slates like this of Ste. Marie are composed in large part of pyrophyllite, a mineral which has many of the physical properties of talc, but is a hydrated silicate of alumina, containing when pure, about 67·0 of silica, 26·0 of alumina and 7·0 of water. Other aluminous silicates may however possess similar physical characters, such as the sericite of List, which is regarded as a hydrous mica, and pholerite, another species about to be described.

Just below the fall of the Chaudière River, near Quebec, there is found in a bed of sandstone belonging to the Quebec group of the Lower Silurian series, and situated on the confines

of the metamorphic region, a peculiar mineral filling up fissures in the rock. This substance is made up of minute, soft scales, very unctuous to the touch, and having a silvery lustre; the masses are greenish or yellowish-white in color, and have but little coherence. Before the blow-pipe the mineral exfoliates in snow-white cauliflower-like masses, but is infusible. It gives off abundance of water when heated in a tube, assumes a fine blue color when ignited after having been moistened with a solution of nitrate of cobalt, and gives a feeble manganese reaction with carbonate of soda.

A portion of the mineral gently crushed to powder was suspended in water, and in this manner separated to a considerable extent from intermixed grains of quartz. Thus purified, it was levigated and dried at 212° F.; the aspect of the powder was not changed by ignition. Analysis gave :—

	I.	II.
Silica,	46·05	45·55
Alumina,	38·37	....
Lime,	·61	....
Magnesia,	·63	....
Water,	14·00	13·90
	99·66	....

There is without doubt an excess of silica in the specimen analyzed, for it was impossible to ensure its freedom from quartz. The pholerites described by Guillemin and those subsequently analyzed by Dr. Lawrence Smith are hydrous silicates, yielding from 40·7 to 44·4 of silica, and from 13·0 to to 15·3 of water, the remainder being alumina with traces of lime and magnesia. The differences in composition are probably due to mechanical impurities, and the mineral in its pure form is no other than a crystalline kaolin, whose theoretical composition as expressed by the formula 3(alO,SiO) +2HO, is silica 40·0, alumina 44·5, water 15·5=100·0. The species kaolin is a product of the decomposition of felspars, which lose their alkali and a portion of silica; these are carried away by solution, at the same time that the residual silicate combines with water. In the case of lime-felspars, and of scapolite, which may also be converted into kaolin, the lime is removed at the same time with the alkalies.

The mode in which this mineral occurs segregated in the fissures of the sandstone at the Chaudière would lead to the supposition that it has been in a state of solution; it may evidently be produced during the decomposition of the clay slates, which are made up to a large extent of the ruins of felspathic rocks. These slates are slowly giving up their alkalies to infiltrating waters, and are thus being converted into kaolin. A great portion of the so-called talcose slates of the Alleghany range, especially those associated with the gold deposites throughout the eastern part of North America, are derived from the alteration of clay-slates, and must be aluminous in their composition. It will be well for the future to distinguish them on account of their lustre, by the name of *nacreous slates* or *nacreous schists.*

Associated with the argillaceous slates of this series there are however great quantities of magnesian rocks; among these, besides serpentine, diallage, dolomite and magnesite, there are extensive beds of compact and schistose talc, and others of well characterized chlorite.

The magnesite which occurs in a very large bed in the township of Bolton, has already been alluded to in the Report for 1849, p. 64. An analysis of it gave:—

Carbonate of magnesia,	60·13
" " iron,	8·32
Insoluble silica,	32·20
	100·65

The insoluble residue from the action of hydrochloric acid, was found to be nearly pure silica, but contains a trace of chromium, while the solution contains besides magnesia and protoxyd of iron, a small portion of nickel. The nickel in fact forms greenish stains in the fissures of the rock, and associated with chrome, has been found in the ferruginous magnesite of Sutton. The chromic iron of Ham also contains traces of nickel and cobalt, and nickel appears to be present in many of the serpentines and other magnesian rocks of the Silurian series, both in Canada and Pennsylvania. The various analyses by different chemists of magnesian minerals from

other regions, show that olivine, talc and kæmmererite often contain traces of nickel.

Ores of Nickel.

Small portions of nickel occur in several parts of the Province, and in other associations than those just mentioned. Among the Laurentian rocks in the eleventh concession of Daillebout, on the land of Mr. Louis Levèsque, there occurs on the bank of the Assumption River a quartz vein six or eight inches wide in gneiss. This vein holds a considerable amount of cubic iron pyrites, which contains small quantities of nickel and cobalt. The amount of the mixed oxyds of the two metals was found in two determinations to be only 0·54 and 0·56 per cent.

Some specimens furnished me by Mr. Charles Bonner (who aided me in several of the analyses,) from a mine on Michipicoten Island, (Lake Superior,) contains two minerals which offer a more abundant source of nickel than the pyrites just mentioned. The first of these is associated with quartz, and is a massive mineral with an impalpable structure, a shining metallic lustre, and a color varying from reddish-white to bronze-yellow; brittle, fracture uneven, sub-conchoidal; hardness 5·0; density 7·35 to 7·40. The mineral was at first supposed to be nickeline or arseniuret of nickel, but the result of several analyses shows it to consist of a mixture of this species with an arseniuret of copper. The following are the results of four analyses of different fragments detached from the same mass:—

	I.	II.	III.	IV.
Arsenic,	37·36	44·67		
Copper,	44·70	30·81	27·60	10·28
Nickel,	17·03	24·55	27·29	36·89
Silver,	.....	·25	·21	
	99·09	100·28		

It will be apparent from the following calculations that these different specimens are mixtures of nickeline Ni^2As, and

domeykite Cu^6As, the former containing 44·1 of nickel and 55·9 of arsenic, and the latter 71·7 of copper and 28·3 of arsenic. For the first analysis 44·70 parts of copper require 17·67 of arsenic to form 68·37 of domeykite, and 17·03 of nickel unite with 21·57 of arsenic to form 38·60 of nickeline, requiring in all 39·24 parts of arsenic, while the analysis gives 37·36 parts, besides a deficiency of 0·91, which probably corresponds to a loss of arsenic. For the fourth analysis we have only 10·28 of copper, requiring 4·05 of arsenic to form 14·33 of domeykite, and 36·89 of nickel, which demand 46·74 of arsenic, giving 83·63 of nickeline, the two amounting to 97·96 parts for 100·00 of the mineral. The nickel contained traces of cobalt. It is desirable that this locality should be farther examined, for an ore so rich in nickel is very valuable. The arseniuret of copper, which evidently predominates in some portions of the mass, is as yet a very rare species.

Another ore of nickel, said to be from the same mine as the preceding, occurs as the gangue of native copper and native silver, which are disseminated through it in grains. The mineral is amorphous; color greenish-yellow to apple green; lustre waxy; sub-translucent, fracture conchoidal; very soft, polishes under the nail, and falls to pieces when immersed in water. It is decomposed by acids with separation of pulverulent silica. The analysis of this material showed the presence of silica, alumina, oxyds of nickel and iron, lime, magnesia and water; it yields moreover, traces of copper and cobalt, but no arsenic. Two portions of the mineral carefully freed from the disseminated metals gave the following results. The specimen in the first analysis had been dried at 212° F., the other at a higher temperature, and had lost a portion of water.

	I.	II.
Silica,	33·60	35·80
Alumina,	8·40	11·00
Protoxyd of iron,	2·25	
Oxyd of nickel,	30·40	33·20
Lime,	4·09	3·81
Magnesia,	3·55	3·37
Water,	17·10	12·20
	99.39	99.38

Another fragment containing the native metals in small grains, gave me silver 2·55, copper 18·51, and oxyd of nickel 20·85 per cent. It is said that a large quantity of this valuable ore was thrown away at the mine, being stamped and washed for the purpose of extracting the copper and silver.

This substance can hardly be supposed to be homogenous in its composition, being not improbably a result of the alteration of some other ores. It resembles closely in its character and composition the nickel-gymnite of Genth, which gave to that chemist, silica 35·36, oxyd of nickel 30·64, oxyd of iron 0·24, magnesia 14·60, lime 0·26, and water 19·09; but neither of these hydrated nickel ores are crystalline, and they are perhaps, rather to be regarded as mechanical mixtures than distinct mineral species.

I have the honour to be,

Sir,

Your most obedient servant,

T. STERRY HUNT.

REPORT

FOR THE YEAR 1855,

OF

T. STERRY HUNT, Esq., CHEMIST AND MINERALOGIST TO THE GEOLOGICAL SURVEY,

ADDRESSED TO

SIR WILLIAM EDMOND LOGAN, F.R.S., DIRECTOR OF THE GEOLOGICAL SURVEY OF CANADA.

MONTREAL, 1*st October*, 1856.

SIR,

Having been absent from the country during nearly the whole of the year 1855, the usual course of my investigations was interrupted. In the month of June in that year I was appointed by the Imperial Commission of the *Exposition Universelle* at Paris, to be a member of the 1st class of the International Jury, a class specially charged with the examination of all subjects connected with mining, metallurgy, mineralogy and geology. I have now at your request prepared a report upon such of those matters which fell under my notice, during my duties as juror, as may be of interest to the Canadian public. I do not propose to attempt a report upon the objects of the 1st class at the Paris Exhibition, but simply to notice at some length certain processes connected with the metallurgy of iron, the manufacture of sea-salt and other salts from sea-water, besides some points in connection with the manufacture and economical application of cements, bitumen, peat, etc.

The new metallurgical processes of Adrien Chenot attracted in a particular manner the attention of the Jury at the Palace of Industry, and were the object of a special study by the 1st class, who awarded to the inventor the *Gold Medal of Honour*. M. Chenot there exhibited a series of specimens serving to illustrate the processes which bear his name, and which have been the result of extraordinary labors on his part, continued through the last twenty-five years. As the industry of iron-smelting promises for the future to be one of great importance to Canada, it may be well to advert briefly to the history and theory of the metallurgy of iron, in order to explain the processes now in use, and to prepare the way for an exact understanding of those of Chenot.

The most ancient and simplest mode of obtaining iron from its ores is that practiced in the Corsican and Catalan forges, where pure ores are treated with charcoal in small furnaces, and by variations in the mode of conducting the process, are made to yield at once either malleable iron, or a kind of steel. But this method requires very pure ores, and a large expenditure of fuel and labour, while from the small size of the furnaces it yields but a limited quantity of iron. It is scarcely used except in the Pyrennees, Corsica, some parts of Germany, and northern part of the State of New York.

The high or blast furnace, which converts the ore directly into cast metal, furnishes by far the greater part of the iron of commerce. This furnace may be described as consisting essentially of a crucible in which the materials are melted, surmounted by a vertical tube or chimney some thirty feet in height, in which the reduction of the ore is effected. Into this furnace a mixture of ore and fuel is introduced from the top, and the fire, once kindled, is kept up by a blast of hot or cold air, supplied by a proper apparatus, and admitted near the bottom of the furnace. The ores submitted to this process are essentially combinations of iron with oxygen, often containing besides water and carbonic acid, and always mingled with more or less earthy matter, consisting of silica, alumina, &c. The water

and carbonic acid being readily volatile, are often expelled by a previous process of roasting. When these oxyds of iron are heated to redness in contact with charcoal, this material combines with the oxygen of the ore, and the iron is set free or reduced to the metallic state, after which by the further action of the combustible it is fused, and collects in a liquid mass in the crucible below. The earthy ingredients of the ore, with the ashes of the fuel, are also melted by the intense heat, and form a glassy substance or *slag*, which floats upon the surface of the molten metal, and from time to time both of these are drawn off from the crucible It is very important to give to these earthy matters that degree of fluidity which shall permit their ready separation from the reduced and melted iron, and to attain this end the different ores are generally mixed with certain ingredients termed fluxes, which serve to augment the fusibility of the slags. Limestone, sand and clay may each of them be used for this object with different ores. It will be kept in mind that the fuel employed in the process of smelting, serves for two distinct objects; first, as a combustible to heat the materials, and secondly, as a reducing agent to remove the oxygen from the ore.

The contents of a blast furnace in action consist then of a great column of mingled ore and fuel, continually moving downward towards the crucible, and constantly replenished from the top, while a current of air and gases is constantly traversing the mass in a contrary direction. The investigations by Leplay and Ebelman of the theory of this operation have prepared the way for the processes of Chenot, and we shall therefore state in a few words, the results of their researches. They have shown in the first place, that the direct agent in the reduction of the ore is a portion of the carbon of the fuel in a gaseous state, and secondly, that this reduction is effected at a temperature far below that required for the fusion of the metal. The oxygen of the air entering by the blast, is at first converted by combination with the ignited coal, into carbonic acid, in which an atom of carbon is combined with two atoms of oxygen, but as this gas rising in the the furnace encounters other portions of ignited coal, it takes

up another equivalent of carbon and forms carbonic oxyd gas, in which the two atoms of oxygen are combined with two of carbon. This gas is the reducing agent, for when in its upward progress it meets with the ignited oxyd of iron, the second atom of carbon in the gas takes from the iron two atoms of oxygen to form a new portion of carbonic acid, which passes on, while metallic iron remains.

The interior of the blast furnace may be divided into four distinct regions; the first and uppermost is that in which the mixture of ore and fuel is roasted; the water and volatile matters are there driven off, and the whole is gradually heated to redness. In the second region, immediately below the last, the already ignited ore is reduced to the metallic state by the ascending current of carbonic oxyd gas; the metal thus produced is, however, in the condition of malleable iron, nearly pure, and very difficultly fusible; but in the third region is it combines with a portion of carbon, and is converted into the fusible compound known as cast iron. In addition to this, small portions of magnesium, aluminium and silicium, whose combinations are always present in the contents of the furnace, become reduced, and alloying with the iron affect very much its quality for better or worse, Cast iron generally contains besides these small portions of sulphur, phosphorus, and other impurities less important.

In the fourth and lowest region of the furnace, which is near to the blast, the heat becomes more intense, the carburetted metal melts, together with the earthy matters, and both collect at the bottom of the crucible upon what is called the hearth, from which the two are drawn off from time to time. The cast iron thus obtained is very fusible, but brittle, and is far from possessing those precious qualities which belong to malleable iron or steel.

To convert the cast metal into malleable iron, it is exposed to a process which is called *puddling*, and consists essentially in fusing it in a furnace of a peculiar kind, where the metal is exposed to the action of the air. The carbon, manganese, silicium, and other foreign matters, are thus burned away, and the once liquid metal is converted into a pasty granular mass,

which is then consolidated under hammers or rollers, and drawn out into bars of soft malleable iron.

To convert into steel the soft iron thus obtained, it is heated for a long time in close vessels with powdered charcoal, a small quantity of which is absorbed by the iron, and penetrating through the mass changes it into steel. This process is known by the name of *cementation.* The change is however irregular and imperfect; it is therefore necessary to break up these bars of cemented or blistered steel, as it is called, and after assorting them according to their quality, either to weld them together, or to melt down each sort by itself in large crucibles. The metal is then made into ingots, and forms cast steel, which is afterwards wrought under the hammer and drawn out into bars.

Such is an outline of the long and expensive processes by which malleable iron and steel are obtained from the ores of iron. The reduction of the iron to the metallic state constitutes but a small part of the operation and consumes comparatively but little fuel, but as we have already seen that reduced iron is first carburetted as it descends in the furnace, then melted by an intense heat into the form of cast iron, which is again fused in the puddling furnace before being converted into malleable iron, the transformation of which into cast steel requires a long continued heat for the cementation, and still another fusion.

In Derbyshire in England, there are consumed for the fabrication of one ton of cast iron, two tons and twelve quintals of ore and two tons of mineral coal, while in Staffordshire two tons eight quintals of coal, and two tons seven quintals of ore are employed for the production of a ton of cast metal. In the furnaces of the Department of the Dordogne, in France, where wood charcoal is employed, two tons and seven quintals of ore, and one ton and three quintals of charcoal are employed for a ton of iron. For the production of a ton of wrought iron in England about one ton and one-third of cast iron, and from two to two and a-half tons of mineral coal are consumed, while the same amount of the cast iron of the Dordogne requires to convert it into a ton of wrought iron, one ton and

a-half of charcoal. Thus in England the fabrication of a ton of wrought iron, from poor ores yielding from thirty-eight to forty per cent. of metal, requires a consumption of about five tons of mineral coal, and in Dordogne a little over three tons of wood charcoal, which costs there about fifty-eight shillings currency the ton. The average price of charcoal in France, however, according to Dufrénoy, is about seventy-four shillings, while in Sweden it costs only about fourteen shillings, and in the Ural Mountains eleven shillings the ton. In France much of the pig iron manufactured with charcoal is refined by the aid of mineral coal.

The questions of the price and the facility of obtaining fuel are of the first importance in the manufacture of iron. The ores of this metal are very generally diffused in the earth's surface, and occur abundantly in a great many places where fuel is dear. The iron which is manufactured either wholly or in part with wood charcoal, is of a quality much superior to that obtained with mineral coal, and commands a higher price. One principal reason of this difference is that the impurities present in the coal contaminate the iron, but it is also true that the ores treated with mineral coal are for the greater part of inferior quality. Interstratified with the beds of coal in many parts of Great Britain, Europe and North America there are found beds of what is called *clay ironstone*, or argillaceous carbonate of iron, yielding from twenty to thirty-five per cent. of the metal. This association of coal with the ore offers great facilities for the fabrication of iron, which is made in large quantities, and at very low prices from these argillaceous ores.

These poor ores will not admit of being carried far for the purpose of smelting, and it is not less evident that the large quantity of coal required for their treatment could not be brought from any great distance to the ores. As a general rule the richest and purest ores of iron belong to regions in which mineral coal is wanting, while the carboniferous districts yield only poorer and inferior ores. On this continent, which contains vast areas of coal-bearing rocks, the great deposits of magnetic and hematitic iron ores are chiefly confined to the

mountainous district north of the Saint Lawrence, and the adjacent region of northern New York, to which may be added a similar tract of country in Missouri. In the old world it is in Sweden, the Ural Mountains, Elba and Algiers, that the most remarkable deposits of similar ores are met with; and it is not, perhaps, too much to say, that if favourable conditions of fuel and labour were to be met with in these regions, these purer and more productive ores would be wrought to the exclusion of all others. But obliged to have recourse to wood charcoal, the forests in the vicinity of large iron furnaces are rapidly destroyed, and fuel at length becomes scarce. In a country like ours where there is a ready market for fire-wood near to the deposits of ore, the price of fuel will one day become such as to preclude their economic working by the ordinary processes. As the industrial arts progress, the consumption of fuel is constantly increasing, and its economical employ becomes an important consideration.

From these preliminaries it is evident that a great problem with regard to the manufacture of iron, is to find a process which shall enable us to work with a small amount of fuel, those rich ores which occur in districts remote from mineral coal. Such was the problem proposed by Adrien Chenot, and which in the opinion of the International Jury, he has in a great measure resolved.

To return to the blast furnace; we have seen that the second and moderately heated region is that in which the reduction of the ore is effected, and that the intense heat of the lower regions of the furnace only affects the carburation and fusion of the metal. M. Chenot conceived the idea of a furnace which should consist only of the roasting and reducing regions; his apparatus is but the upper portion of an ordinary blast furnace, the carburetting and fusing regions being dispensed with. In this the ore is reduced at a low red heat, and the metal obtained in the form of a gray, soft, porous mass, constituting a veritable metallic sponge, and resembling spongy platinum. The furnace of Chenot is a vertical prismatic structure forty feet high, open at the top for the

reception of the ore, and having below a moveable grate by which the charge can be removed; the bottom is susceptible of being closed air-tight. The lower part of the furnace is of iron plate, and is kept cool, but about mid-way the heat is applied for the reduction of the ore, and here comes in a most important principle, which will require a particular explanation. It is required to heat to moderate redness the entire surface of the rectangular vertical furnace throughout a length of several feet, a result by no means easy to be effected by the use of a solid combustible, but readily attained by a gaseous fuel such as is employed by M. Chenot.

We have already explained the theory of the production of carbonic oxyd. The possibility of employing this gas as a combustible was first suggested by Karsten, and in 1841 M. Ebelman of the School of Mines at Paris, made a series of experiments on the subject by the direction of the Minister of Public Works. The process employed by this chemist consisted essentially in forcing a current of air through a mass of ignited coal of such thickness that the whole of the oxygen was converted into carbonic oxyd; this escaping at an elevated temperature was brought into contact with the outer air, and furnished by its combustion a heat sufficient for all the ordinary operations of metallurgy. A consideration of great importance connected with this process is, that it permits the use of poor earthy coals, and other waste combustibles, which could hardly be employed directly, while by this method the whole of their carbonaceous matter is converted into inflammable gas. Wood and turf may be made use of in the same way, and the gas thus obtained will be mingled with a portion of hydrogen, and probably with some hydrocarburet: a similar mixture may be obtained with charcoal or anthracite, if a jet of steam be introduced into the generating furnace, a modification of the process which has however the effect of reducing the temperature of the evolved gases.

This mode of employing combustibles becomes of great importance in the process of Chenot, who generates the gas in small furnaces placed around the great prismatic tube, and

conducts it into a narrow space between this and an outer wall; through this by openings, a regulated supply of air is introduced for the combustion of the gas, by which the ore contained in the tube is raised to a red heat. The next step is to provide the reducing material which shall remove the oxygen from the ignited ore, and for this purpose we have already seen, that even in the ordinary smelting process carbonic oxyd is always the agent; but instead of the impure gas obtained from his furnaces, and diluted with the nitrogen of the air, M. Chenot prefers to prepare a pure gas, which he obtains as follows. A small quantity of pure carbonic acid, evolved from the decomposition of carbonate of lime, is passed over ignited charcoal, and thus converted into double its volume of carbonic oxyd gas; this is then brought in contact with ignited oxyd of iron, which is reduced to the metallic state, while the gas is changed into carbonic acid, ready to be converted into carbonic oxyd by charcoal as before. In this way the volume goes on doubling each time the two-fold operation is repeated. By introducing the carbonic oxyd thus obtained into the furnace charged with ignited iron ore, and withdrawing a portion of the gas at a higher level, for the purpose of passing it again over ignited charcoal in a smaller tube apart, the process may be carried on indefinitely, the carbonic acid serving as it were to carry the reducing combustible from the one tube, to the ore in the other.

A modification of this process consists in mingling the ore with an equal volume of small fragments of charcoal, and admitting a limited supply of air into the body of the apparatus, by openings at mid-height, the heat being as before applied from without. In this case the action is analogous to that which takes place in the ordinary blast furnace: carbonic oxyd and carbonic acid are alternately formed by the reactions between the oxygen of the air, the ore and the charcoal; but the supply of air being limited, and the temperature low, neither carburation nor fusion of the metal can take place, and five-sixths of the charcoal employed remain unchanged and serve for another operation. This simpler way has the disadvantage that one-half of the furnace is

occupied with charcoal, so that the product of metal is less than when the reducing gas is prepared in a separate generator. In either case the product is the same, and the iron remains as a soft porous substance, retaining the form and size of the original masses of ore. This metallic sponge is readily oxydized by moisture, and if prepared at a very low temperature, takes fire from a lighted taper, and burns like tinder, yielding red oxyd of iron. In order to avoid the inconvenience of this excessive tendency to oxydation, the metal is exposed in the process of manufacture to a heat somewhat greater than would be required for the reduction; this renders the sponge more dense, and less liable to oxydation in the air.

The part of the furnace below the action of the fire is so prolonged, that the reduced metal in its slow descent, has time to become very nearly cold before reaching the bottom. It is then removed at intervals, by an ingenious arrangement, which enables the operator to cut off, as it were, the lower portion of the mass, without allowing the air to enter into the apparatus. In the case where the ore has been mixed with charcoal, the larger masses of metal are now separated from it by a screen, and the smaller by a revolving magnetic machine.

This spongy metallic iron may be applied to various uses. If we grind it to powder and then submit it to strong pressure, coherent masses are obtained, which at a welding heat, contract slightly, without losing their form, and yield malleable iron. By this process of moulding, which may be termed a casting without fusion, the metal may be obtained in forms retaining all the sharpness of the mould, and possessing the tenacity, malleability and infusibility of wrought iron. The masses thus compressed have in fact only to be forged, to give wrought iron of the finest quality; and it is found that during the hammering, any earthy matters mechanically intermixed, are eliminated like the scoriæ of the iron from the puddling furnace.

But without overlooking the great advantage of this method of making malleable iron, and moulding it into the shapes

required, it is especially as applied to the manufacture of steel, that the metallurgical methods of Chenot deserve attention. In the ordinary process, as we have already seen, the bars of malleable are carburetted by a prolonged heating in the midst of charcoal powder; but the operation is long and expensive, and the metal obtained by this mode of cementation is not homogeneous. M. Chenot avails himself of the porosity of the metallic sponge, to bring the carbon in a liquid state in contact with the minutest particles of the iron. For this purpose he plunges the sponge into a bath of oil, tar, or melted resin, the composition of the bath varying according to the quality of the steel which it is desired to obtain. The sponge thus saturated, is drained, and heated in a close vessel. The oily or resinous matter is expelled partly as a gas, but for the greater part distils over as a liquid, which may be again employed for cementation. A small portion of carbon from the decomposition of the oil rests however with the iron, and at the temperature of low redness, employed near the end of the distillation, appears to have already combined chemically with the metal. This treatment with the bath and distillation, may be renewed if the carbonization is not sufficient after one operation.

The cemented sponge is now ground to powder and moulded by hydraulic pressure into small ingots, which may be heated and directly wrought under the hammer, like the compressed iron sponge; the metal thus obtained may be compared to refined blistered steel. If however the cemented and compressed sponge is fused in crucibles, as in the ordinary process for making cast steel, the whole of the earthy impurities which may be present, rise to the surface as a liquid slag, which is easily removed, while the fused metal is cast into ingots. In this way, by cementation and a single fusion, the iron sponge is converted into a cast steel, which is from the mode of its preparation, more uniform in quality than that obtained by the ordinary process, and which was found by the Jury to be of remarkable excellence.

Such is a brief outline of the methods invented by Adrien Chenot for the reduction of iron ores, and the fabrication of

wrought iron and steel, constituting in the opinion of one eminently fitted to judge the case, (Mr. Leplay, of the Imperial School of Mines, and Commissary General of the Exhibition,) the most important metallurgical discovery of the age.

The peculiar condition of the iron sponge has enabled the inventor to make many curious alloys, some of which promise to be of great importance; by impregnating it with a solution of boracic acid, a peculiar steel is obtained, in which boron replaces carbon, and by a similar application of different metallic solutions, various alloys are produced, whose formation would otherwise be impossible.

The processes of M. Chenot are now being applied to the fabrication of steel at Clichy, near Paris, where I had an opportunity of studying in detail the manufacture. The iron ore is imported from Spain, and notwithstanding the cost of its transport, and the high prices of labor and fuel in the vicinity of the metropolis, it appears from the data furnished by M. Chenot to the Jury, that steel is manufactured by him at Clichy, at a cost which is not more than one-fourth that of the steel manufactured in the same vicinity from the iron imported from Sweden. According to M. Chenot, at the works lately established on his system by Villalonga & Co., near Bilboa in Spain, they are enabled to fabricate the metallic sponge at a cost of 200 francs the ton, and the best quality of cast steel at 500 francs, or $100 the ton of 1000 kilogrammes, (2·200 pounds avoirdupois.) The conversion of the ore to the condition of sponge is, I was assured by M. Chenot, effected with little more than its own weight of charcoal.

The differences in the nature of the steel made from various ores have long been well known, but until the recent experiments of Chenot, the subject was but very imperfectly understood. According to him the nature of the ore has much more to do with the quality of the metal than the mode of treatment, and he compares the different steels to the wines of different localities, which owe their varied qualities far more to the nature of the grapes, than to any variations in the mode of their fermentation. The process of cementation employed by Chenot furnishes, according to him, an exact measure of the

capability of the iron to produce steel. The sponges of the iron from Sweden and the Ural Mountains, after taking up six per cent. of carbon, yield a metal which is still malleable, while that of Elba with four per cent., becomes brittle and approaches to cast iron in its properties. While the ores of Sweden and the Urals are famous for the excellent quality of their steel, the ore of Elba is known to yield a very superior iron, but to be unfit for the fabrication of steel; and Chenot concludes, from a great many observaticns, that the steel-producing capacity of any iron is measured by the quantity of carbon which it can absorb before losing its malleability and degenerating into cast iron.

Desirous to avail myself of these researches of M. Chenot, I placed in his hands, in September, 1855, specimens of the different iron ores from Canada, which had been sent to the Exhibition at Paris, and engaged him to submit them to the process of reduction, and to test their capabilities for the production of steel. M. Chenot has also obtained remarkable alloys of chromium and titanium with iron, his processes enabling him to effect the direct reduction of chromic and titaniferous iron ores; specimens of these two ores from Canada were therefore furnished him, but the sudden and lamented death of Chenot, by an accident, in the month of November following, deprives us for a time of the advantages of his experiments. His sons however are instructed in his processes, and have promised to undertake at an early day the examination of our Canadian ores. I am disposed to attach great importance to these investigations, from the hope that among our numerous deposits of iron ore, belonging in great part to the same geological formation as the iron ores of Scandinavia, there may be found some capable of yielding a steel equal to that of the Swedish iron. With the new and economical processes of Chenot a valuable steel ore will be sought for, even in a distant country, and may be advantageously transported in a crude state, to the localities where fuel and labour are most available.

One great condition for the successful application of these processes is, that the ores should be comparatively pure and

free from earthy mixtures. We have already alluded to the impurity of the ores which are smelted in the coal districts of England, and even the ore brought by Chenot from Spain, and employed by him in his works at the gates of Paris, contains about ten per cent. of fixed, and as much volatile matter, it being a decomposed spathic iron. Many of the magnetic and hematite ores of Canada are almost chemically pure: such are those of Marmora, Madoc, Hull, Crosby, Sherbrooke, MacNab and Lake Nipissing, which even if they should not prove adapted to the manufacture of superior steel, offer for the fabrication of metallic iron, by the processes of Chenot, very great advantages over the poorer ores, which in many parts of this continent are wrought by the ordinary processes.

The small amount of fuel required by the new methods, and the fact that for the generation of the gas which is employed as combustible, turf and other cheap fuels are equally available, are considerations which should fix the attention of those interested in developing the resources of the country. With the advantages offered by these new modes of fabrication, our vast deposits of iron ore, unrivalled in richness and extent, may become sources of national wealth, while by the ordinary method of working they can scarcely, at the present prices of iron and of labour, compete with the produce of much poorer ores, wrought in the vicinity of deposits of mineral coal.

ON THE EXTRACTION OF SALTS FROM SEA WATER.

The manufacture of salt from the waters of the ocean has, from an early period, been a most important branch of industry for the south of Europe. Without reverting to high antiquity, we may cite the salines of Venice, to which that republic owed the commencement of its greatness and its wealth. The lagoons which surrounded that city were enclosed, and set apart for the breeding of fish, and for the manufacture of salt. Making a monopoly of this staple of life, the policy of Venice was to obtain possession of all those salines which could compete with her, and we find the Venetians destroying such as they could not make use of, and exacting from the neigh-

bouring princes, treaties to the effect that they would not re-establish the suppressed salines. It was only two or three centuries later that this powerful republic ordered, in the interest of her commerce, the suppression of the salines of her own lagoons, and augmented the produce of those of Istria and of the Grecian Islands, which had become her's by right of conquest, still retaining in her own hands the trade in salt for all southern Europe. But with the downfall of Venitian power, we find the salines of Provence and Languedoc growing into importance, while those of Venice had fallen into decay, so that when the Emperor Napoleon I. created the kingdom of Italy, he had recourse to a French engineer from Marseilles to re-establish the salines of Venice, which are now once more organised on a vast scale.

It is however in France, and especially upon the shores of the Mediterranean, that we shall find the most extensive salines, and the most intelligent system of working these great sources of national wealth. On the western coast of France, the salt marshes of Brittany and La Vendée are wrought to a considerable extent, but the cool, moist and rainy climate of these regions is much less favorable to this industry than that of the southern shores of the empire, where dry and hot summers offer great facilities for the evaporation of the sea-water, which is effected in all the salines of which we have spoken, by the sun and wind, without artificial heat.

The salt works of the Lake of Berre, near Marseilles, were those whose products attracted the most attention at the Exhibition, not only on account of the excellent method there pursued for the manufacture of sea-salt, but from the fact that the important processes of Mr. Balard for the extraction of potash, sulphates and other valuable materials from the mother liquors, are there applied on a large scale. Having had occasion to examine carefully these products in the course of my duties as Juror at the Exhibition, and having afterwards visited the saline of Berre, I propose to give here some account of its construction and mode of operation, as well as of the method employed for the working of the mother liquors. I have to express my great obligations to my distinguished

colleague, Mr. Balard, of the Academy of Sciences, who most kindly furnished me with every information respecting the processes of his invention which are there applied, and also to Mr. Agard, the enlightened and scientific director of the saline.

The first condition for the establishment of a salt work is a low, broad, level ground on the border of the sea, which can be protected by dykes from the action of the tides, and as these are considerable on the Atlantic coast and insignificant in the Mediterranean, the arrangements required in the two regions are somewhat different. In both cases however the high tides are taken advantage of to fill large and shallow basins with the sea water, which there deposits its sediments, becomes warmed by the sun's rays and begins to evaporate. From these reservoirs it is led by a canal to a series of basins from ten to sixteen inches in depth, through which it passes successively, and where by the action of the sun and wind the water is rapidly evaporated, and deposits its lime in the form of sulphate. It then passes to another series of smaller basins, where the evaporation is carried to such a point that the water becomes a saturated brine, when its volume being greatly diminished, it is transferred to still smaller shallow basins called *salting tables*, where the salt is to be deposited. In the salines of the Atlantic coast, the different basins are nearly on the same plane, and the water flows from one series to the other as its level is reduced by evaporation. In the large establishments of the Mediterranean, the system is different; the basins are constructed at different levels, and the waters having passed through one series, are raised by wooden tympans or drums from eight to sixteen feet in diameter, (moved by steam or horse power,) and conducted into the other basins. There differences of level establish a constant current, and in this way greatly promote the evaporation.

But in whatever manner the process is conducted, the concentrated brines, making 25° of Beaumé's areometer, are finally conducted to the salting tables, where they begin to deposit their salt in the form of crystalline crusts, which are either collected with rakes as soon as they form, or as at Berre,

allowed to accumulate at the bottom, until they form masses six or eight inches in thickness. The concentration of the brines must be carefully watched, and their density never allowed to exceed 28°5, otherwise a deposit of sulphate of magnesia would be formed, rendering the sea-salt impure. The mother liquors, as they are called, are run off so soon as they have reached the above density, and reserved for operations to be detailed further on. When the salt has attained a sufficient thickness, it is broken up and piled upon the sides of the basins in large pyramids, which are covered with clay on the western coast of France, but left unprotected during the summer season, in the dry climate of the south. In these heaps, the salt undergoes a process of purification; the moisture from the clay or from occasional rains penetrates slowly through the mass, removing the more soluble foreign matters, and leaving the salt much purer than before. In the south, it is taken directly from these heaps and sent into the market, but in the less favorable conditions presented on the western coast, the thin layers of salt there collected are more or less soiled with earthy matters, and for many uses require a process of refining before they are brought into commerce. For this purpose two methods are employed; the one consists in simply washing the crude salt with a concentrated brine, which removes the foreign salts, and a large portion of the earthy impurities. The other more perfect, but more costly process, consists in dissolving the impure salt in water, and adding a little lime to precipitate the salts of magnesia always present, after which the filtered brine is rapidly boiled down, when a fine-grained salt separates, or is more slowly evaporated to obtain the large-grained cubic salt which is used in the salting of provisions. The masses of coarsely crystalline salt from the salines of the south have no need of these refining processes.

In practice, the evaporation of the brines for sea-salt at Berre is carried as far as 32°, and the salt separated into three qualities. Between 25° and 26° the brine deposits one-fourth of its salt, which is kept apart on account of its great purity, and sold at a higher price than the rest. In passing from a

density of 26° to 28°5, sixty per cent. more of salt of second quality are deposited, and from this point to 32° the remaining fifteen per cent. are obtained, somewhat impure and deliquescent from the magnesian salts which it contains, but prefered for the salting of fish, on account of its tendency to keep them moist. The average price of the salt at the salines is one franc for 100 kilogrammes, (220 pounds avoirdupois,) while the impost upon it was, until recently, thirty times that sum, and is even now ten francs the 100 kilogrammes.

The waters of the Mediterranean contain, according to the analysis of Usiglio, about three per cent. of common salt, while those of the Atlantic contain from 2·5 to 2·7 per cent. In the waters of the Mediterranean there are besides, about 0·8 per cent. of sulphates and chlorids of calcium, magnesium and potassium. The quantity of water which it is necessary to evaporate in order to obtain a small amount of salt, thus appears to be very great, but under favorable circumstances this is a small consideration, as will appear from the following fact. The saline of Berre is situated upon a small lake, communicating with the ocean, but fed by streams of fresh water, so that while the waters of the open sea have a density of 3°5, those of the lake have only 1°5, or scarcely half the strength of sea water. Nevertheless the advantages of the position offered by the shores of the lake for the establishment of a saline, are sufficient to compensate for the deficiency of salt in the water, and to make of Berre one of the most flourishing salines of the south of France. The evaporating surfaces here cover 3,300,000 square metres, equal to 815 English acres; of this area one-tenth is occupied with the salting tables, but with sea-water, where less evaporation is required to bring the brine to the crystallizing point, one-sixth of the area would be thus occupied. The amount of salt annually produced at saline of Berre is 20,000,000 of kilogrammes.

Owing to the dilution of the water of the lake of Berre, the proportion of salt there manufactured is small, when we consider the area, and compare the produce with that of other salines where pure sea-water is evaporated. According to Mr. Balard, 2,000,000 square metres may yield 20,000,000

kilogrammes annually; and Mr. Payen states that the same amount of salt is produced at Baynas from a superficies of 1,500,000 metres. As a cubic metre of sea water contains about 25 kilogrammes of salt, the evaporation required to produce the above amount corresponds to 800,000 cubic metres, equal in the second estimate given above, to a layer of water 0·40 metre, or 15¾ English inches in thickness.

The plan hitherto adopted in the salines of the European coasts, has been to commence the evaporation of the sea-water with the spring time of each year; in this way some three or four months elapsed before a sufficiently large amount of strong brine was accumulated to enable the manufacturer to commence the deposition of salt on the salting tables, and as this latter operation can only be carried on in fine weather, the rainy season of autumn soon came to interrupt the process, so that during a large part of the year the labours of the salines were suspended. The enlightened director of the works of Berre, M. Felicien Agard, has however introduced a very important improvement, in the management of the salines, by means of which he carries on the works throughout the whole year, and is enabled to increase the produce by 50 per cent. During the months of the autumn, the evaporation, which is still carried on, though more slowly, enables him to obtain brines marking 7°, 10°, and even 20°. These are stored away in large pits, where the depth of liquid being considerable, the diluting effect of the spring rains is but little felt, and at the commencement of the warm season these brines are raised into the evaporating basins, so that the summer's labours are commenced with concentrated liquors, and the salt is all harvested in the months of August and September.

In selecting the site for a saline it is of great importance to choose a clayey soil, an earth of this character being required to render the basins and dykes impervious to water. In the saline of Berre, a coriaceous fungous plant, to which botanists have given the name *Microcoleus corium*, was observed to vegetate upon the bottom of the basins, and this being carefully protected, has finished by covering the clay with a layer like felt, which protects the salt from contamination by the earth, and enables it to be collected in a state of great purity.

The conditions of exposure to sun and wind offered by the locality chosen for a saline are also to be carefully considered, for upon these will of course greatly depend the rapidity of evaporation. The salines of the lagoons of Venice, to which we have already alluded, have recently been re-organised by Baron S. M. Rothschild and Mr. Chas. Astric, and cover an area nearly twice that of Berre. The tides of the Adriatic are considerable, and from the lowness of the ground, the labour of constructing the basins and dykes could only be carried on at low water. The moist and rainy climate of Venice also offers serious obstacles to the manufacture of salt; to overcome these, two plans are adopted. The salting tables are so arranged that in case of heavy rains, the concentrated brines can be rapidly run off into deep reservoirs, while other reservoirs of saturated brine at higher levels serve not only to feed the salting tables, but to cover with a thick layer those tables which may contain a large amount of salt, and thus protect them from the atmospheric waters.

We may mention here a process which, although unknown in France, is applied in Russia and on the borders of the White Sea, and may, perhaps, be advantageously employed on our own shores. It consists in applying the cold of winter to the concentration of the sea-water. At a low temperature a large quantity of ice separates, but all the saline matters rest in the liquid portions, so that by separating the ice a concentrated brine is obtained, which may afterwards be evaporated by the summer's sun or by artificial heat.

Treatment of the Bittern or Mother Liquors.

The waters which have reached a density of 32° in the salting tables, have already deposited the greater part of their common salt, and now contain a large amount of sulphate and hydrochlorate of magnesia, together with a portion of chlorid of potassium. The admirable researches of Mr. Balard have taught us to extract from these mother liquors, sulphate of soda, and salts of magnesia and potash, so that although formerly rejected as worthless, these liquors are now almost as valuable as the salt of which they are the residue.

The production of sulphate of soda, which is directly employed in the manufacture of glass, and as a manure, and still more largely as a material for the fabrication of carbonate of soda, is the most important object of the working of the mother liquors. Immense quantities of sulphate of soda are now prepared in France and England by decomposing sea-salt with sulphuric acid, which is manufactured with sulphur obtained chiefly from foreign sources. In view of this immense consumption of sulphur, it becomes important especially in time of war, when this substance is required for the fabrication of gunpowder, to find some source of sulphate of soda other than the decomposition of sea-salt by sulphuric acid. This process is besides objectionable from the vast amount of hydrochloric acid disengaged, which in most localities cannot be entirely consumed, and is very pernicious to both animal and vegetable life in the vicinity.

It had already been observed that under certain conditions the reaction between sulphate of magnesia and chlorid of sodium could give rise to sulphate of soda; and Mr. Balard has shown that by taking advantage of this decomposition, the sulphate of soda can be advantageously prepared from the bittern of the salting tables.

When the liquors of 32° are evaporated by the summer's heat, they deposite during the day a portion of common salt; but the coolness of the nights causes the separation of crystals of sulphate of magnesia, and the quantity of this latter salt goes on increasing as the evaporation advances toward 35°. This mixture of salts (A) is carefully collected, and reserved for the manufacture of the sulphate of soda.

When the bittern at 35° is still further evaporated by the heat of the sun, it deposits a mixture which is called *sel d'été*, and contains a large amount of potash. By a second crystallization of this product, a double sulphate of potash and magnesia is obtained, which holds 24 per cent. of pure potash; but this mode of treating the mother liquors of 35° is less advantageous than the following, which is now adopted. The liquors are placed in large basins and preserved until the first frosts, when at a temperature of 35° or 40° Farenheit, they deposit

the greater part of their sulphate of magnesia in large crystals. This sulphate, which is pure Epsom salt, is either sold to the apothecaries, or used to prepare sulphate of soda by the process about to be described. When the sulphate of magnesia has been thus separated, the liquid is run off into large reservoirs, and preserved until the next summer, when it is again evaporated in shallow basins by the sun's rays. It now deposits a large amount of a fine granular salt, which is a double chlorid of potassium and magnesium. This double salt can only be crystallized from solutions containing a large quantity of chlorid of magnesia, and when re-dissolved in pure water gives pure chlorid of potassium by evaporation. The double chlorid is raked up from the tables and placed in piles on the earth, where the moisture causes the salt to decompose; the magnesian salt deliquescing, drains off, and the chlorid of potassium remains behind.

The mother liquors having acquired a density of 38°, have deposited all their potash, and are now evaporated by artificial heat to 44°; during this evaporation they still deposit a portion of common salt mixed with sulphate of magnesia (B), and on cooling, the liquid becomes a solid mass of hydrated chlorid of magnesium, which may be employed to furnish caustic and carbonated magnesia by decomposition. When calcined in a current of steam, it is completely decomposed into hydrochloric acid and an impure magnesia, still containing some sulphates and chlorids, which may be removed by water.

By mingling in proper proportions the solution of chlorid of magnesium at 44° with brine at 24°, nearly the whole of the sea-salt is precipitated in the form of minute crystals of great pureness and beauty; the mother liquors are then removed by washing with a saturated brine, and in this way a very fine quality of table salt may be advantageously manufactured.

During these successive concentrations the volume of the water has become greatly diminished. 10,000 gallons of sea-water reduced to 25°, (the point at which it begins to deposit salt,) measure only 935 gallons; at 30°, 200 gallons; at 31° 50 gallons; and at 34°, are reduced to a volume of only 30 gallons.

Preparation of Sulphate of Soda.

For this process the cold of autumn and winter is required. The mixtures of sea-salt and sulphate of magnesia, (A and B,) together with the pure sulphate of magnesia obtained from the mother liquors at 32°, are dissolved in water heated to 95° F., with the addition of such a quantity of common salt as shall make the proportions of the two salts equal to 90 parts of chlorid of sodium to 60 of anhydrous sulphate of magnesia. The warm saturated solution is exposed in shallow basins to a cold of 32° F., when it deposits 120 parts of hydrated sulphate of soda, equal to 54 of anhydrous sulphate, or three-fourths of the sulphuric acid of the mixture. In theory, about equal weights of the two salts are necessary for their mutual decomposition, but an excess of common salt diminishes the solubility of the sulphate of soda, and thus augments the product. From the residual liquid, which contains chlorid of magnesium mixed with common salt and a portion of sulphate of magnesia, the latter salts may be separated by evaporation. The sulphate of soda is converted into carbonate of soda by the usual process of calcination with carbonate of lime and coal.

The Potash Salts.

The chlorid of potassium obtained by the process already indicated, is decomposed by sulphuric acid, and the resulting sulphate at once converted into carbonate of potash by a process similar to that employed for the manufacture of carbonate of soda. The carbonate of potash thus prepared is free from sulphate and chlorid, as well as from silica and alumina, and those metallic impurities which like iron and manganese, are always present in the salt obtained from wood-ashes, and render the potashes of America and Russia unfit for the fabrication of fine crystal glass. The double sulphate of potash and magnesia may be at once decomposed like the sulphate of potash, by limestone and coal, and both it and the chlorid may be directly employed in the fabrication of

potash-alum, a salt which contains nearly ten per cent. potash, and of which five thousand tons are annually manufactured in France. The high price of the salts of potash has led the manufacturers of alum, to replace this alkali wholly or in part by ammonia, but the potash salts from sea-water will furnish potash so cheaply as to render the use of ammonia no longer advantageous.

The greater part of chlorid of potassium as yet produced in the salines in the south of France is now, however, employed chiefly in the Imperial manufactories of saltpetre or nitrate of potash. The nitrate of soda which is so abundant in some parts of South America, is directly decomposed by chlorid of potassium, yielding common salt and pure nitrate of potash for the fabrication of gunpowder.

Yield of the Mother Liquors.

According to a calculation of Mr. Balard the amount of sulphate in sea-water corresponds to a quantity of anhydrous sulphate of soda equal to one-eight that of the common salt, but on a large scale the whole of this cannot be economically extracted: the saline of Baynas yields annually besides 20,000 tons of sea-salt, 1,550 tons of dried sulphate of soda, or 7·75 per cent., instead of the 12·50 per cent. indicated by theory. Estimating the yield at 7·0 per cent. according to Payen, the cost of the sulphate will be 30 francs the ton, which will make the cost of the crude carbonate of soda 50 francs, while it brings in France from 80 to 120 francs the ton.

The amount of chlorid of potassium obtained is equal to one-hundredth or to 200 tons for the above amount of sea-salt, and the value of this salt is 360 francs the ton. By its decomposition it will yield 185 tons of pure carbonate of potash, which sells for 1000 or 1100 francs the ton. Thus it appears that for 20,000 tons of sea-salt, worth at 10 francs the ton, 200,000 francs, there is obtained chlorid of potassium for the value of 72,000 francs. The potash being a secondary product from the residues of the processes for sea-salt and sulphate of soda, is obtained almost without additional cost.

It has been shown by careful calculations that the sulphate of soda and the potash from the waters of the Mediterranean, will alone repay the expense of extraction, the sea-salt first deposited, being re-dissolved and carried back to the ocean. A powerful company is now erecting works on a great scale in the vicinity of Marseilles, where the marshes of the Camargue offer a great extent of waste lands, valueless for cultivation, but well adapted for this manufacture. Here it is proposed to evaporate the sea-water solely for the sake of the sulphates, the potash and the magnesia which it contains. Basins which are already covered with a layer of sea-salt, are very advantageously employed for the evaporation of the mother liquors, from the ease with which the potash and magnesia salts may be collected from it in a state of purity.

The amount of salt produced in France in 1847 was about 570,000 tons, of which 263,000 were from the salt-marshes of the Mediterranean, 231,000 from those of the western coast, and 76,000 from salt-springs and a mine of rock salt; there were employed in these 16,650 workmen. If we estimate the produce of the salt marshes in round numbers at 500,000 tons, the amount of chlorid of potassium to be obtained from the mother liquors, at one per cent., will be 5000 tons, and that of the sulphate of soda at seven per cent. will be 35,000 tons. The amount of sulphate of soda annually manufactured in France is 65,000 tons, requiring for this purpose 54,000 tons of sea-salt, and nearly 14,000 tons of sulphur, which is completely lost in the manufacture of carbonate of soda.* If now the mother liquors from an area twice as great as is now occupied by all the salines in France, were wrought with the same results as at Baynas, they would

* The soda manufactory of Chaunay, established in connection with the glass works of St. Gobain, consumes above 5,000 tons of sulphur yearly, and the immense establishment of Tennant, at St. Rollox, near Glasgow, employs annually 17,000 tons of salt, 5,550 of sulphur and 4,500 tons of oxyd of manganese. It produced in 1854, 12,000 tons of soda-ash, 7,000 of crystallized carbonate of soda, besides 7,000 tons of chlorid of lime, prepared with the chlorine obtained by decomposing the waste hydrochloric acid from the soda process by the oxyd of manganese. The cost of the sulphur in England in 1854 was about twenty-five dollars the ton.

yield besides 70,000 tons of sulphate of soda, or more than is required for the wants of the country, 10,000 tons of chlorid of potassium, equal to 9,250 tons of pure carbonate of potash, a quantity far greater than is consumed in France, and would enable her to export potash salts. According to Mr. Balard the consumption of potash in France amounted in 1848 to 5,000 tons, of which 3,000 were imported, and 1,000 tons extracted from the refuse of the beet-root employed in the manufacture of sugar.

The production of the two alkalies, potash and soda, offers some very interesting relations. Previous to the year 1792, soda was obtained only by the incineration of sea-weed and maritime plants, but it was at that epoch, when France was at war with the whole of Europe, that her necessities led to the discovery of a mode of extracting soda from sea-salt. Obliged for the purposes of war to employ all the potash which the country could produce, for the manufacture of saltpetre, it became necessary for the fabrication of soaps and glass to replace this alkali by soda, and therefore to devise some more abundant source of it that was afforded by sea-weed. It was then that the Government having offered a prize from the most advantageous method of extracting the soda from sea-salt, Leblanc proposed the process above alluded to, which consist in converting the chlorid of sodium into sulphate, and decomposing this salt by calcining it with a proper mixture of ground limestone and coal, thus producing carbonate of soda and an insoluble oxy-sulphuret of calcium. This remarkable process, perfect from its infancy, has now been adopted throughout the world, "and those who thought to annihilate the industry of France were soon obliged to borrow from her those great resources which French science had invented." (*Payen, Chimie Industrielle*, p. 209.)

Soda has now replaced potash to a very great extent in all those arts where it can without prejudice be substituted for the latter; potash is however indispensable for the manufacture of fine crystal and Bohemian glass, for the fabrication of saltpetre, as well as for the preparation of various other salts

employed in the arts. The country people in France having been accustomed to employ the crude American potash for the bleaching of linen, were unwilling to make use of the purer soda-ash, and the result is that a great part of what is sold as American potash in France, is nothing more than an impure caustic soda, coloured red with sub-oxyd of copper, and fused with an admixture of common salt, which serves to reduce its strength, and give it the aspect of the crude potash of this country.

But notwithstanding the soda from sea-salt is now replacing potash to so large an extent, the supply of this alkali is scarcely adequate to the demand, and the consequence is that while the price of soda has greatly diminished, that of potash has of late years considerably augmented, and it has even been proposed to extract this alkali from felspar and granitic rocks, by processes which can hardly prove remunerative. The rapid destruction of the forests before the advancing colonization of this continent, threatens at no distant day to diminish greatly the supplies of this as yet important production of our country, and it was therefore a problem of no small importance for the industrial science of the future, to discover an economical and unfailing source of potash. The new process of Mr. Balard appears to fulfil the conditions required, and will, for the time to come, render the arts independent of the supplies to be derived from vegetation.

In more ways than one, this result will be advantageous for our country; the importance of potash salts as a manure, is now beginning to be understood, and it is seen that the removal from the land in the shape of ashes, of the alkali which during a century has been taken up from the earth and stored in the growing forest, is really an unwise economy, for the same alkali restored to the soil becomes a fertilizer of great value. It is to be feared too that in many parts of the country, the colonist wishing to render the forest available as an immediate source of gain, has thought rather to cut down and burn the wood for the sake of its ashes, than to cultivate the land thus cleared. The effect of this short-sighted policy in thus destroying our forests, is already beginning to be seriously

felt in some parts of our country, where the early settlers looking upon the forest as their greatest enemy, sought only to drive back its limits as fast and as far as possible, and have thus left the borders of the St. Lawrence nearly destitute of wood, so that the cultivator is often obliged to bring from a distance of many miles that fuel, which in a country like ours, is such an important necessary of life, and now commands in our large towns a high price, which is annually increasing. But apart from their value as sources of fuel, the importance of occasional forests in breaking the force of winds, and tempering both the cold blasts of winter, and the heat and dryness of the summer, should not be overlooked in a country which like ours, is exposed to great extremes of temperature. The unwise policy which formerly levelled with an unsparing hand the forests of Provence, has rendered portions of that country almost a desert, exposed to the strong winds which descend from the Alps. Future generations may plant forests where we are now destroying them.

But to return from this digression; it is worthy of consideration whether the extraction of salt from sea-water, for the internal consumption of the province, as well as for the supply of the immense fisheries on our coasts, might not be made a profitable branch of industry. The shores of the lower St. Lawrence, or of the Bay of Chaleurs, would probably afford many favorable localities for the establishment of salines; the heat of our summers, which may be compared to those of the south of France, would produce a very rapid evaporation, while the severe frosts of our winters might be turned to account for the concentration of the water by freezing, as is practiced in northern Russia. Experiments would enable us to determine how far the concentration can be carried during the winter months, and whether this process could be advantageously employed during the cold season, in preparing strong brines for the summer. The sulphates of magnesia and soda, and the potash salts, would find a ready market in England, if the consumption of carbonate of soda and soda-ash in the province, should not be found sufficient to warrant the establishment of furnaces for the manufacture of these alkalies in the country.

In the construction of a saline it would be necessary to choose a locality where is a considerable extent of nearly level surface between the lines of high and low water. High embankments would be necessary to protect the evaporating ground against the tides of our coasts, but these once constructed, the high tides would enable us to fill reservoirs at such an elevation as would carry the water by its own gravity through a series of basins, and thus dispense, in a great measure at least, with the elevating machines employed in the salines of the Mediterranean.

I have given these suggestions, and have entered into many details of the process of working the salines, from a conviction of the great importance of this industry as now developed in France, and from a hope that some persons may be induced to inquire whether these processes may not be economically applied upon our own coasts.

MAGNESIAN MORTARS.

The attention of several chemists has been of late years turned to the study of cements and mortars, but it is especially to the laborious and admirable researches of Mr. Vicat of Grenoble, that we are indebted for a complete elucidation of some of the most important questions connected with the subject. The ordinary mortars composed of lime and sand, harden gradually by exposure to the air, and this process depends upon two distinct reactions; first, the absorption of carbonic acid from the air, and the formation of a sub-carbonate of lime, and secondly, upon a partial combination of the lime with the sand, forming a silicate of lime. When placed under water however, and excluded from the influence of carbonic acid, mortars thus composed do not harden, but become dissolved or disintegrated; they cannot therefore be employed for constructions which are submerged.

Certain limestones have long been known to yield mortars or cements, which have the property of hardening under water, and the pozzuolanas of Italy and some other countries, when mingled with ordinary lime, yield mortars which are possessed

of similar properties. Pozzuolanas, and these peculiar limestones are comparatively rare; but Vicat has shown that it is possible to imitate them in a very simple manner, and with materials which are everywhere present, to prepare good hydraulic cements. The limestones which yield hydraulic cements are those which are mingled with a certain proportion of clay, and by calcining an artificial mixture of carbonate of lime and clay, we may prepare hydraulic cements, varying in character according to the proportions of the mixture. When the limestone contains 10, 15, or 25 per cent. of clay, it becomes more and more hydraulic, and when the mixture amounts to one-third of the lime, we obtain a mortar which hardens almost immediately in air or under water. The proportion of clay may even rise to 60 per cent.

The name of Roman cement is applied to a mixture of this sort, but incorrectly, as the preparation of such a cement was unknown to the Romans. The *pozzuolana* or *trass*, which was employed by them to give hardness to their mortars, is a felspathic or argillaceous matter, which has been calcined by volcanic heat, and has thus acquired the property of rendering ordinary lime hydraulic. It suffices, in fact, to calcine any ordinary clay, especially with the addition of a little alkali, to obtain an artificial pozzuolana.

The well-known Portland cement (so called because its colour resembles that of the Portland stone,) is prepared by calcining a mixture in proper proportions, of chalk with the clayey mud of the Thames; but similar and equally good cements are now manufactured elsewhere in England and France by mixing chalk or marl with other clays. The materials are reduced to fine powder, and intimately mixed with the addition of water. The resulting paste is moulded into bricks, which are dried and burned. It is of importance that the heat in calcining be sufficiently elevated, otherwise the carbonic acid and water may be expelled without that reaction between the lime and clay which is required for the production of a cement. It is necessary to employ a white heat, which shall agglutinate and frit the mixture. After this operation the material is assorted, and the portions which

are scorified by too much heat, as well as those insufficiently calcined, being set aside, the cement is pulverized for use. It is often advantageous to grind to powder the native mixtures of limestone and clay before burning them, in order to ensure greater homogeneousness. It will also be seen that a calcination at a very elevated temperature is frequently required to develope the hydraulic character of limestones; the greater the temperature employed, the more slow is the solidification of the cement, but the harder does it become.

The portions of cement which have been over-heated and converted into a slag, as well the semi-vitrified masses obtained in the calcination of ordinary lime, over-burned bricks and tiles, and the scoriæ of iron-furnaces, may all be used with advantage to give hydraulic properties to ordinary lime, either by mingling with it before burning, or by employing them as pozzuolanas to mix with the slacked lime. The theory of the solidification of these various cements, and the important part played by the alkali which is always present, in forming a silicate of lime, has been carefully studied by Kuhlmann and Fuchs; the application of soluble glass for the silicatisation of limestones and other calcareous materials, depends upon a similar reaction. But important as is this question, both in a theoretical and practical point of view, I shall reserve it for another occasion.

The cements prepared by the different processes above indicated, leave nothing to be desired for constructions in fresh water, but do not uniformly resist the action of the sea, which causes a great many of these hydraulic cements to lose their cohesion, and eventually fall to pieces when immersed in sea-water. Mr. Vicat, junior, has found that this change depends upon the action of the magnesian salts of the sea-water upon the lime of the cement, and has proposed a mortar from which lime is excluded, consisting of caustic magnesia mixed with an artificial pozzuolana. For this purpose such materials should be selected as contain no calcareous matter, and he recommends pipe-clay, or the debris of certain felspathic rocks. These when calcined and mixed with 15 or 20 per cent. of magnesia, previously made into a paste with water, yield a

cement which hardens after three or four days, either under fresh or salt water, and acquires after some time a great degree of strength.

But important as this discovery of Mr. Vicat promises to be, the high price of magnesia is opposed to the general adoption of this cement for marine constructions. The inventor calculates that if magnesia can be furnished for $30 or $40 the ton, the cement can be economically made use of, and the directors of the salines of the south of France are now endeavoring to manufacture magnesia on a large scale, from the chlorid of magnesium in the bittern of the sea water. Carbonate of magnesia is abundant in nature, but almost always found united with carbonate of lime, forming a dolomite, and the pure magnesian carbonate has hitherto been a rare mineral. Associated with a little carbonate of iron and some silicious matters however, it is found in abundance in the Eastern Townships, where it forms beds among the Silurian slates in Sutton and Bolton. Specimens of it from these localities attracted particular attention at the Exhibition at Paris, where the magnesian mortar of Vicat was first brought forward, and the Reporter of the Jury of the 14th class calls particular attention to the value of this mineral as a source of magnesia, and as possibly destined to become an article of export from Canada.

The magnesite from Bolton, where it forms an immense bed, resembles a crystalline limestone, and consists of about 60.0 per cent. of carbonate of magnesia, 9.0 per cent. of carbonate of iron, and 31.0 of quartz in grains, besides small portions of nickel and chrome. Some specimens from Sutton contain more than 80.0 per ct. of carbonate of magnesia. When this mineral is calcined, the carbonic acid is expelled, and there remains a mixture of magnesia with quartz and oxyd of iron. But as these impurities do not interfere with its application to the purposes of a cement, the previously ignited rock, which in the case of that from Bolton will contain 43.0 per cent. of caustic magnesia, may be directly mixed with calcined clay or pozzuolana, to form the magnesian mortar. Although it is not certain that these native carbonates can be economically wrought for exportation, the subject is certainly worthy of the

attention of our engineers who are engaged in the construction of docks and piers in the lower ports of the St. Lawrence. At the same time the application of this mineral as an economical source of pure magnesia and magnesian salts on a large scale, is one worthy of consideration.

ON THE PURIFICATION OF PLUMBAGO.

Mr. Brodie, of London, presented at the Exhibition a quantity of plumbago purified by a new and remarkable process, which excited the attention of the Jury not less by its economic importance, than by the curious chemical reaction upon which it depends. The pure plumbago furnished by the mines of Borrowdale in Cumberland, is exceedingly fine-grained, and so compact that it may be sawn into thin plates, which are used for the fabrication of pencils. This plumbago, as is well known, commands an enormous price, and the locality is now nearly exhausted. Many other countries, as Bohemia, Spain, Ceylon, Greenland and Canada furnish abundance of the mineral, but it is almost always impure from the presence of earthy matters, and generally so crystalline in its texture that it cannot be wrought by the same processes as the Cumberland lead.

Attempts had been made to reduce these varieties to powder, and then to consolidate them by the aid of some adhesive matter, but these results were not satisfactory. Mr. Brockedon at length conceived the happy idea of solidifying the powder by pressure, without the intervention of any foreign substance; but it was necessary first to remove the air from between the particles, for without this precaution, all attempts to compress it resulted only in the breaking of the instruments employed. The prepared mineral, moulded by a slight pressure into a mass of the required shape, was enveloped in very fine paper, covered over with glue. Having made a small round hole in the paper, the parcel was placed beneath the receiver of an air-pump; the air being exhausted, the aperture in the paper was closed by a small disc of the same glued paper, and the parcel being withdrawn, was then submitted to a heavy pres-

sure, which caused the adhesion of the particles, and gave masses of graphite equal in beauty and solidity to the native mineral of Cumberland. For this ingenious invention the Jury of the Exhibition of 1851 awarded to Mr. Brockedon the Council Medal.

But to give its full value to the discovery of Mr. Brockdon, there was still wanting a means of purifying the ordinary plumbago, and removing the earthy matters with which it is generally contaminated. To effect this is one of the objects of the process of Mr. Brodie. He mixes the plumbago in coarse powder, in an iron vessel, with twice its own weight of common sulphuric acid, and seven per cent. of chlorate of potash, and heats the whole over a water-bath until chloric oxyd ceases to be evolved. By this means the compounds of iron, lime and alumina present, are rendered for the most part soluble, and the subsequent addition of a little fluorid of sodium to the acid mixture, will decompose any silicates which may remain, and volatilize the silica present. The mass is now washed with abundance of water, dried, and heated to redness. This last operation causes the grains of plumbago to exfoliate, and the mass swells up in a surprising manner, and is reduced to a state of very minute division. It is then levigated, and obtained in a state of great purity, ready to be compressed by the method of Brockedon.

The process of Mr. Brodie is now patented in England, and a manufactory established for the refining of plumbago by this method. Besides its use for the fabrication of pencils, this finely divided plumbago is advantageously employed for the glazing of gunpowder, and according to Mr. Brodie, for the preparation of a paint. Its freedom from earthy impurities must give it a great superiority over ordinary plumbago as an application for preventing friction in machinery.

Mr. Brodie asserts that his process is peculiarly applicable to the purification of the lamellar variety from Ceylon, which resembles closely that found in Grenville and Burgess; and I have found by trial that it succeeds admirably well with our Canadian plumbago.

ON PEAT, AND THE PRODUCTS DERIVED FROM IT.

Within a few years much has been said about the economical applications of peat, not only as a combustible in a compressed state, or converted into charcoal; but also as a source of oils, paraffine, illuminating gas and ammoniacal salts. My attention was therefore naturally directed to this matter while at the Exhibition, and I had an opportunity of examining collections of these products from various parts of France, and obtaining considerable information upon the subject.

There are several deposits of peat which furnish the supply of this material for the Paris market. A portion of a large peat bog near Liancourt (Oise) which is on the Northern Railway, nineteen leagues from Paris, is now wrought by Messrs. Debonne & Co., and it is to the kindness of Mr. Debonne, that I am indebted for the following facts with regard to his establishment. The layer of peat has an average thickness of ten feet, and the working, which is carried on during five months in the year, employs 300 men. The peat from the top and bottom of the bog is mixed, and being transferred to flat-boats, is turned over with shovels, and trampled beneath the feet of the workmen, after which it is moulded with pressure into the form of small bricks, which when dried are heavier than water. The moulded peat is worth in Paris 20 francs the ton of 1,000 kilogrammes (2,204 pounds avoirdupois.) The quantity annually raised by Debonne & Co. is from 10,000 to 12,000 tons, all of which was in 1855 converted upon the spot into charcoal, of which it yields from 40 to 42 per cent. This charcoal is sold in Paris at wholesale for 100 francs the ton, and retailed at the rate of 13 francs the 100 kilogrammes. This was about the price of wood-charcoal at Paris in 1855, when mineral coal was sold there at from 4·00 francs to 5·00 francs the 100 kilos, and wood at from 4·0 to 5·5 francs for the same weight, or by measure at from 35 to 38 francs the *stère* of 35·3 cubic feet English. The dried peat yields from 10 to 11 per cent. of ash, and the charcoal 27 per cent.; its combustion is slower than that of ordinary charcoal, and it is much employed for domestic purposes in Paris.

Mr. Hebert of Reims, (Marne) prepares a large quantity of compressed peat of excellent quality, amounting to 14,000 tons annually, a part of which is manufactured into charcoal. The peats and charcoals prepared by the patented process of Challeton at Clermont-Ferrand (Puy-de-Dome), and Montauger (Seine-et-Oise), were remarkable for their homogeneousness, density and cheapness, and attracted particular attention at the Exhibition. They are said to be economically employed for stationary steam-engines, and even for locomotives. His coal yields 28 per cent. of ash.

In the ordinary process for carbonizing peat, its volatile products are lost, but when distilled in close vessels it yields besides water, ammonia, and inflammable gases, a large amount of oily matter. According to Mr. Armand, the skilful chemist of the establishment of Babonneau & Co., of Paris, good peat yields on an average about forty per cent. of charcoal, and fifteen to eighteen per cent. of crude oil containing paraffine. 1000 kilogrammes of the compressed and dried peat of Liancourt, still containing fifteen per cent. of hygrometric moisture, gave to him 400 of charcoal, 167 of oils, bitumen and paraffine, 358 of water, containing carbonate, acetate and sulphydrate of ammonia, and a little wood spirit; besides 75 kilogrammes of inflammable gases and loss. The ammonia was equal to 20 kilogrammes of sal-ammoniac. The oil by distillation is separated into a light oil or naphtha, which is burned for illumination in lamps of a peculiar construction, and a heavy, less volatile portion, which is used for lubricating machinery, or is mingled with fat oils for burning in ordinary lamps. There is obtained besides, a portion of solid bitumen or pitch, amounting for the above quantity to 48 kilogrammes.

The application of peat charcoal as a manure, either alone or mingled with animal matters, for which its great antiseptic power makes it admirably adapted, is a consideration not to be overlooked. It has a much greater de-odorizing effect than ordinary charcoal, while the inorganic salts which it contains will enhance its value as a manure. I have already called attention to this latter point in my Report for 1850, where I have shown that the peat of St. Dominique, which yields

thirty-six per cent. of charcoal, gives from six to seven per cent. of ash, containing besides carbonates and silicates of lime and magnesia, more than one per cent. of alkaline salts, two per cent. of phosphate of lime, and fifteen per cent. of sulphate of lime. It will be observed that this peat contains much less ash than that of Liancourt.

The paraffine, which is dissolved in the oils, is separated from them by exposure to cold, and afterwards purified by peculiar processes. According to Mr. Armand, peat may be made to yield from two to three per cent. of this matter. When pure it is a white, fusible, crystalline solid, devoid of taste or smell, much resembling spermaceti in appearance, and like it employed for the manufacture of candles. For this purpose it is said to be mixed with eight or ten per cent. of ordinary stearine, (stearic acid,) and to yield candles of great beauty, hardness and illuminating power. It is also advantageously mingled in smaller quantities with stearine, or even with common tallow, to which it communicates hardness and other valuable properties. The price of the pure refined paraffine at the Exhibition, was given as 250 francs the 100 kilogrammes, (220 pounds,) or about half the price of spermaceti.

The gas evolved during the distillation of the peat may be employed as a combustible for heating the retorts, but it burns with too pale a flame to be used for illuminating purposes. The crude oil from the peat however, when decomposed by a high temperature, as in the manufacture of gas from oil or resin, yields a gas of great illuminating power, which when mingled with the gaseous product of the first distillation, gives a gas of very superior quality. Experiments made in 1855 with this mixed gas, showed that its illuminating power was three and four-tenth times that of coal gas, but I am not able to state the comparative cost of the two. From the absence of sulphur in peat, the purification of this gas would be much more simple than that from coal.

The solid bitumen from the distillation of peat may be employed like asphalt in the preparation of mastic for paving, and I have been assured that experiments have shown that peat itself may be converted into a similar material, by the

following process. Having been well dried, it is mingled with from ten to fifteen per cent. of coal-tar, and the mixture boiled for several hours, until the peat disolves into a viscid liquid, which when cooled, is solid and resembles asphalt.

The distillation of bituminous shales, and mineral bitumens is carried on to a great extent both in England and on the continent. To this class of matters belong the so-called Boghead and cannel coals, as well as the bituminous minerals of various parts of France and Switzerland. These substances afford by distillation products similar to those of peat. The crude oil from bituminous schists yields by rectification, a considerable amount of solid bitumen, but only a small quantity of paraffine, of which peat promises to be the most abundant and economical source. The price of the rectified oils for illuminating purposes, was quoted in Paris at from 40 francs to 75 francs the hectolitre, which is equal to 22 imperial gallons. A peculiar unctuosity is said to be given to the denser oils by the addition of a little lime, which thickens them, and renders them better adapted for lubricating purposes, but these oils, it is said, cannot replace those of animal or vegetable origin, for machines where great velocity is required. Large quantities of mineral oils are however now manufactured for these purposes, both in England and France; a similar product is also obtained by the distillation of resin.

The crude residues from the rectification of the oils of peat and bitumen are burned in proper apparatus, and furnish abundance of lamp-black. The solid bitumen, which is obtained in considerable quantity from bituminous schists, is employed with the native asphalt, for the preparation of the mastics, now so much used for pavements and the covering of roofs and walls. The house of Babonneau & Co., in Paris, which conducts the working of the bitumens of Val de Travers in Switzerland, of Chavaroche in Savoy, and of Rocca Secca near Naples, has establishments for distilling on a large scale these various minerals, and the extraction of the products already mentioned. To Mr. Babonneau, and to M. Armand, the able chemist of the company, I am much indebted for their kindness in affording me information. Mr. Armand informed me that bitumi-

nous shales cannot be economically wrought in France unless they yield five per cent. of bituminous matter, the residue from the distillation being, unlike that from peat, comparatively worthless. The distillation of peat appears to be as yet in its infancy, and probably destined to become a very important branch of industry.

The Canadian bitumen from Enniskillen is properly an inspissated petroleum, and yields when distilled a great deal of oil containing paraffine; it will probably be more advantageously employed as a source of lubricating and illuminating oils, than an asphalt.

I have the honour to be,

Sir,

Your most obedient servant,

T. STERRY HUNT.

REPORT

FOR THE YEAR 1856,

OF

T. STERRY HUNT, Esq., CHEMIST AND MINERALOGIST TO THE GEOLOGICAL SURVEY,

ADDRESSED TO

SIR WILLIAM EDMOND LOGAN, F.R.S., DIRECTOR OF THE GEOLOGICAL SURVEY OF CANADA.

MONTREAL, 1*st* *April*, 1857.

SIR,

I have the honour to submit to you the results of my investigations during the past year, having reference to the mineralogy of the metamorphic rocks of the country. In the Reports for 1853 and 1854, I had occasion to describe the felspathic and hypersthenic rocks of the Laurentian series, with its limestones and dolomites. I have now to call your attention to some of its serpentines and other magnesian minerals, and at the same time to show that the metamorphic Lower Silurian region offers a series of rocks very closely analogous in chemical and mineralogical constitution to those of the Laurentian formation. The carbonates and silicates of lime and magnesia are there repeated, and a felspathic rock, allied to diorite, replaces the triclinic felspars and hypersthenites of the older series. The mineral species garnet, which sometimes forms a rock in the Laurentian series, plays an important part in

connection with the serpentines and diallage of the Silurian period, and gives rise to some remarkable varieties of rocks; notwithstanding these parallelisms, there are however characteristic differences between the two series, which may serve to shew some light upon the mode of formation of these strata.

Finally, in connection with a great number of analyses of these altered rocks, and of various unaltered sedimentary deposits of the Silurian series, I have to mention briefly a series of enquiries, commenced in the hope of being enabled to explain the mode of formation of certain sediments, and the production of the various minerals of the altered rocks, from the metamorphism of the sedimentary strata. I shall commence by a description of several varieties of magnesian and other rocks from the Silurian series.

SILURIAN ROCKS.

Serpentines or Ophiolites.—In your Report of 1847, you have described the serpentines of the Green Mountains as occurring in beds, interstratified with the limestones, dolomites, quartzites, argillites, talcose and chloritic rocks, which belong to the altered Hudson River group of the Lower Silurian strata of the eastern basin. The mineral species serpentine, is essentially a hydrous silicate of magnesia, and its composition, according to the received formula, is represented by silica 43·7, magnesia 43·3, water 13·0, = 100·0; a portion of protoxyd of iron, sometimes amounting to ten per cent., frequently replaces an equivalent quantity of magnesia. Besides, as serpentine is rarely crystallized, it may often include foreign minerals, and the result is that the analyses of this species from different regions, offer slight variations, especially in the proportions of silica and water.

The rocks known as serpentines are variable in their constitutions, being sometimes composed almost entirely of the silicate just mentioned; at other times this is mingled with other silicates, such as garnet, diallage and hornblende, with quartz, or with carbonate of lime, dolomite or carbonate of magnesia. Mineralogists have therefore distinguished these rocks

by the general names of *ophiolite* and *ophicalce*, Thus we have besides a rock which is composed essentially of serpentine, and may be regarded as the *common* or *normal ophiolite*, varieties characterized by admixtures of garnet, diallage, hornblende and chromic iron ore, which may be respectively designated as *grenatic* or *garnetiferous*, *diallagic*, *hornblendic* and *chromiferous ophiolites*; to these we must add the *quartzose ophiolite* of Brongniart, which is composed of nodules of quartz in a base of serpentine. The *gabbro* of the Italian geologists is a diallagic ophiolite.

The name of *ophicalce* has been given by Brongniart to rocks composed essentially of carbonate of lime and serpentine, or talc. Crystalline limestones which like that of Grenville, hold disseminated grains of serpentine, are designated by him as *granular ophicalce*, while under the name of *reticulated ophicalce* he has described an aggregate of rounded masses of carbonate of lime, cemented by a base of talcose serpentine. In addition to these, the same author describes an aggregate of rounded masses of quartz, green jasper and silicious slate, cemented by serpentine, and several breccias, consisting of angular fragments of quartz, of serpentine, and of jasper, in a paste of serpentine. These rocks he separates from the preceding species under the name of *anagenites* and *breccias*. But such aggregates, in which serpentine is sometimes the paste, and sometimes the imbedded mineral, cannot be separated from certain varieties of ophicalce. Again in this last species the calcareous matter is often replaced by dolomite, and even by crystalline carbonate of magnesia, forming varieties of rock to which the name of ophicalce is no longer appropriate. I therefore propose to unite all these varieties under the general name of ophiolite, and to describe them as *calcareous*, *dolomitic* and *magnesitic ophiolites*, which may be granular, gnessoid, conglomerate, or brecciated in their structure. I have been thus particular in distinguishing these different varieties, because they have doubtless a common origin, and because their study will aid us in getting an idea of the mode of formation of serpentine rocks.

The ophiolites of the Green Mountains often contain diallage, and more rarely actynolite and garnet. Calcareous, dolomitic and magnesitic varieties are common, and are granular, gneissoid, and sometimes conglomerate in their structure. Small portions of nickel and chrome are seldom or never wanting in these rocks, which often contain grains, and even beds of chromic iron. Foliated and fibrous varieties of serpentine are also met with there, constituting the varieties which have been named *baltimorite*, *picrolite* and *chrysotile*. A fine collection of ophiolites from the township of Orford, where these rocks are very extensively displayed, has furnished me with a large number of the specimens about to be described.

The analysis of the serpentines was generally effected by treating the mineral in fine powder, with sulphuric acid diluted with its own volume of water, and heating the mixture in a platinum capsule until acid fumes were evolved; it was sometimes necessary to repeat this process with the undissolved residue.

The purity of the separated silica was in all cases determined by dissolving it with the aid of heat, in a solution of carbonate of soda. The action of a boiling solution of nitrate of ammonia upon the mineral, either before or after ignition, was generally had recourse to, for the determination of any earthy carbonates which might be present.

1. *Normal Ophiolite.*—A very beautiful and homogenous variety of serpentine rock from the tenth lot of the eighteenth range of Orford, was found to have a density of 2.597. It was finely granular in texture, and had a scaly conchoidal fracture; colour deep olive-green, with small bluish veins; it was sub-translucent, and had a highly argillaceous odour. This serpentine holds in very small quantity, disseminated grains of magnetic and chromic iron ores, and contain a little nickel, but no cobalt. When ignited and boiled with a solution of nitrate of ammonia, it gave a trace of magnesia, but no lime. Its analysis yielded :—

Silica,	40·30
Magnesia (by difference),	39·07
Protoxyd of iron,	7·02

Oxyd of nickel,	·26
" " chrome,	(traces.)
Water, by ignition,	13·35
	100·00

2. A fragment of pure serpentine from a conglomerate dolomitic ophiolite about to be described, had a density of 2·622, a blackish-green colour, a conchoidal fracture, and was almost opaque. The pulverized and ignited mineral yielded to nitrate of ammonia, 0·40 of carbonate of lime and 0·27 of carbonate of magnesia. This serpentine contains a small quantity of chromic iron. The oxyd of nickel, determined upon four grammes of the mineral, gave no trace of cobalt before the blow-pipe. Its analysis gave as follows :—

Silica,	42·90
Magnesia,	36·28
Protoxyd of iron,	7·47
Oxyd of nickel,	·15
Chromic iron,	·25
Loss by ignition,	13·14
	100·19

3. I may cite in this place the analysis of a serpentine given in my Report for 1852, p. 99. It forms the rock in contact with the bed of chromic iron ore in Ham, has a hardness of 3·5, and a density of 2·546. It is massive and compact, with a splintery fracture ; colour greenish-white, and translucent. The analysis, which failed to detect either chrome or lime, gave as follows :—

Silica,	43·4
Magnesia (by difference),	40·0
Alumina and oxyd of iron,	3.6
Water,	13·0
	100·0

The associated chromic iron ore gave by analysis 0·22 per cent. of oxyd of nickel, which, fused with borax before the blow-pipe, gave distinct evidence of the presence of cobalt.

4. A characteristic fibrous serpentine *(picrolite)* from the seventh lot of the eighth range of Bolton, has a hardness of 4, and a density of 2·607. It breaks into ligneous masses several inches in length; very compact; fracture splintery; fibres stiff and elastic; shows an oblique cleavage. Colour celandine-green; lustre vitreous, silky; transparent in small fragments; tough, and difficult to pulverize. The finely-sifted powder is completely decomposed by sulphuric acid, and the silica retains the form and lustre of the fibres; the mineral contains apparently as much nickel as 1. Its analysis gave :—

Silica,	43·70
Magnesia,	40·68
Protoxyd of iron,	3·51
Oxyd of nickel (undetermined)	
Water,	12·45
	100·34

5. *Calcareous Ophiolite.*—The specimen of this variety which I have analyzed is from the tenth lot of the sixteenth range of Orford. It is fine grained and sub-crystalline, with a scaly, somewhat conchoidal fracture. Colour, mottled greenish-grey, with an occasional purplish tinge. Translucent on the edges, and resembles, except in colour, many common limestones. In powder, the rock effervesces with acetic acid, even in the cold, and by the aid of heat fifty-seven per cent. of the mass were dissolved, consisting of carbonate of lime, with a little magnesia and a trace of iron. The residue effervesced in the cold with dilute nitric acid, whose action, aided by a gentle heat during half-an-hour, dissolved 10·76 per cent. of carbonate of lime and magnesia, with a little iron, corresponding to a ferriferous dolomite. The pale-green residue from the action of the nitric acid, when dried at 212° F., equalled 32·00 per cent. It was readily decomposed by sulphuric acid, without any effervescence, and had the characters of serpentine. Its analysis gave :—

Silica,	41·20
Magnesia,	32·16
Protoxyd of iron,	11·16
Lime,	·65

Alumina,	2·67
Water,	12·70
	100·54

The portion soluble in acetic acid (I.) and that dissolved in nitric acid (II.) had the following composition for 100 parts:—

	I.	II.
Carbonate of lime,	91·33	49·45
" " magnesia,	8·67	43·68
" " iron, (traces.)		6·87
	100·00	100·00

It will be seen that the dilute acids attack but slightly the serpentine, and that the nitric acid dissolves an intermingled dolomite, which is but little acted upon by the acetic acid. I have taken advantage of this reaction to separate the dolomite from the carbonate of lime in a crystalline magnesian limestone, whose analysis is given in my Report for 1854. The proximate analysis of the rock in question shows it to be a mixture of carbonate of lime, dolomite and serpentine, and we have for 100 parts:—

Soluble in acetic acid,	57·00
" " nitric acid,	10·76
Insoluble, serpentine,	32·00
	99·76

6. *Dolomitic Ophiolite.*—This granular variety is from the shore of Brompton Lake, in the seventh range of the thirteenth lot of Orford. It is fine grained and greyish-green like the last, but somewhat darker in colour, and weathers reddish-brown. Its fracture is uneven and sub-conchoidal, presenting grains of a crystalline spar. A fibrous coating is sometimes apparent in the joints of the rock. Its hardness is about 4. When reduced to powder it did not effervesce with acetic acid like the last, but was readily attached by dilute nitric acid, which removed carbonates of lime, magnesia and iron, with effervescence, leaving a residue of serpentine. A proximate analysis gave 51·9 parts of serpentine, and 48·1 of dolomite = 100·0. The nitric solution contained some manganese and nickel.

The composition of the serpentine left by the nitric acid was :—

Silica,	43·20
Magnesia (by difference),	36·11
Protoxyd of iron with nickel,	8·29
Water,	12·40
	100·00

The dolomite dissolved, gave for 100 parts :—

Carbonate of lime,	49·58
" " magnesia,	46·32
" " iron with manganese,	4·10
	100·00

7. *Dolomitic Ophiolite.*—This rock, also from Brompton Lake, on the twelfth lot of the eighteenth range of Orford, has furnished some fine blocks for ornamental purposes. It is a conglomerate, made up of fragments of serpentine thickly disseminated in a greenish-white dolomitic base. The masses of serpentine vary from a line to more than an inch in diameter, and although rounded, are more or less angular in form. Their colours are various shades of dark green, sometimes appearing nearly black when polished. The analysis of one of these imbedded masses has already been given (No. 2). This rock contains both nickel and chromic iron.

An average specimen of the conglomerate was pulverized for examination. The powder effervesced even in the cold, with acetic acid, which with the aid of heat, took up by prolonged digestion, twenty per cent. of carbonates of lime and magnesia, and 0·2 of oxyd of iron. The soluble portion contained carbonate of lime 88·30, carbonate of magnesia 11·70. The residue from acetic acid effervesced slightly with warm dilute nitric acid, and the solution was found to contain a quantity of magnesia equivalent to 5·68 per cent. of the original mass (11·70 per cent. of magnesian carbonate), besides 1·36 of peroxyd of iron and 0·60 of alumina, but no lime, the whole of that base having been removed by the acetic acid. The residue from the action of nitric acid, was decomposed by fusion with carbonate of soda, and gave :—

Silica,	45·10
Magnesia, (by difference),	34·68
Protoxyd of iron,	6·12
Alumina,	·80
Water.	13·30
	100·00

The residue when ignited, yielded but a trace of magnesia to a boiling solution of nitrate of ammonia, showing that it retained no carbonate; but from the excess of silica it was evident that a partial decomposition of the serpentine had been effected by the nitric acid. In confirmation of this, I found that a second portion of the pulverized rock, when submitted to a prolonged digestion with acetic acid, left 75·5 per cent. of matter dried at 212° F.; this residue gave a feeble effervescence with nitric acid, which by prolonged digestion, took up 13·0 per cent. of magnesia, although when previously ignited, the residue gave to a solution of nitrate of ammonia only a trace of lime, and but 0·3 per cent. of magnesia. Its analysis by fusion with carbonate of soda gave:—

Silica,	43·10
Magnesia,	35·52
Protoxyd of iron,	8·82
Water,	11·90
	99·34

Another specimen of the conglomerate was now pulverized, and eight grammes of it were digested for a long time with boiling acetic acid; the insoluble residue, after levigation, was subjected a second time to the same treatment. The matters thus dissolved, for 100 parts of the mineral, were:—

Carbonate of lime,	7·35
" " magnesia,	7·72
" " iron,	1·78
	16·85

A portion of the residue from the acid was ignited and boiled with nitrate of ammonia, which dissolved a portion of lime equal to 0·3 per cent. of carbonate, and of magnesia equal

to 3·26 of carbonate of magnesia; making a total of 10·98 of carbonate of magnesia to 7·65 of carbonate of lime. The serpentine residue, still containing these 3·56 per cent. of carbonates, gave by analysis with carbonate of soda, the following results:—

Silica, (by difference),	43·93
Magnesia,	35·64
Protoxyd of iron,	7·83
Lime,	(traces.)
Loss by ignition,	12·60
	100·00

A portion of the powder of this last specimen of the conglomerate was ignited for ten minutes over a spirit-lamp, and then boiled with a solution of nitrate of ammonia, so long as a perceptible odour of ammonia was evolved; there were dissolved by this means 6·50 per cent. of carbonate of lime, and 7·65 of carbonate of magnesia.

Veins of from four to six lines in breadth are often met with in this conglomerate. Their walls are covered with a thin layer of pale green serpentine, having a fibrous structure perpendicular to the sides of the vein, upon this is deposited a bluish-white, fine grained dolomite, while in the middle a nearly pure cleavable calcite occurs. The analysis of a portion of this dolomite gave:—

Carbonate of lime,	59·32
" " magnesia,	34·15
" " iron,	4·83
	98··30

8. *Magnesitic Ophiolite.*—In the three preceeding specimens we have examples of ophiolites which are mixtures of serpentine with carbonates of lime and magnesia; in the first the lime is greatly in excess, in the second the two carbonates are united in the proportions required to form a dolomite, while in the third the magnesian carbonate predominates, but from the action of cold acetic acid, it would appear that a portion at least of the carbonate of lime in this specimen, is not in

chemical combination with the magnesian carbonate The history of these rocks would however be incomplete without the description of another variety, in which the carbonate of lime is entirely wanting, and which consists wholly of silicates and carbonates of magnesia and iron. This remarkable rock has not yet been noticed in Canada, but is found in Vermont, in the southern prolongation of the Green Mountains, and constitutes the so-called serpentine marble of Roxbury in that state; it has been examined by Dr. C. T. Jackson and Dr. A. A. Hayes, of Boston.

Dr. Jackson (*American Journal of Science*, II. vol. xxiii., p. 125,) succeeded in separating from the rock a mineral having the composition of serpentine, and describes veins composed of ferriferous carbonat magnesia, and others of ferriferous dolomite, which traverse the mass. According to Dr. Hayes, (Ibid, II. vol. xxi., p. 382,) the rock is an aggregate of fibrous and compact asbestus, talc, chlorite and chromic iron, with angular fragments of talc-schist and argillite; the whole cemented by carbonate of magnesia, which forms according to him, on an average, 38 p. c. of the mass. He has also shewn that the ophiolites of Cavendish, and of Lynnfield in the same region, contain carbonate of magnesia, without any lime. Through the kindness of the above-named gentlemen, I have been turnished with a series of specimens, which have permited me to make a careful examination of the Roxbury ophiolite.

Some portions of the rock appear as a mottled granular mass, having a hardness of about 4·0, with an uneven fracture, and presenting cleavable grains of magnesite; the colors vary from blackish-green to greenish-white, and the rock is susceptible of a high polish. Other specimens are white and crystalline, with numerous greenish-grey bands, the whole arranged in parallel layers, as if stratified, and resembling closely some varieties of gneiss. The rock cleaves with these layers, which contain serpentine and talc, intermingled with carbonate of magnesia. This mineral, as described by Drs. Jackson and Hayes, is nearly pure in the white portions, and has a hardness of 4·0, and a density of 2·99—3·00, according to my determinations. Dr. Hayes found for its composition, carbonic acid 48·80,

magnesia 45·60, talc and a little silica 3·60, silicate of protoxyd of iron 1·96 = 99·96.

This result corresponds closely with my own. I obtained from 100 parts, 2·76 of talc, and 1·82 of silica, besides 2·40 of peroxyd of iron, corresponding to 3·48 of carbonate of iron, the rest being carbonic acid and magnesia, with a little manganese. The greater portion of the iron exists here as carbonate, as is evident from the fact that it is dissolved by a boiling solution of nitrate of ammonia; but there is also present a portion of silicate of iron and magnesia, decomposable by acids. In my analysis the powdered magnesite was digested for a long time at a boiling heat with hydrochloric acid; the insoluble portion was then boiled with strong sulphuric acid, and from the residue the silica was removed by a solution of carbonate of soda, the talc remaining.

The talc thus purified from magnesite and serpentine by successive treatments with hydrochloric and sulphuric acid and carbonate of soda, was gently ignited, and then decomposed by fusion with carbonate of soda; it gave :—

Silica,	62·60
Magnesia,	31·30
Alumina and oxyd of iron,	4·06
Water and loss,	2·04
	100·00

In the analysis of Dr. Hayes just cited, the 48·80 parts of carbonic acid are sufficient only for 44·36 parts of magnesia, leaving 1·24 of this base in the form of a silicate decomposable by sulphuric acid. In order to determine the composition of this silicate, a dark-green portion of the rock was pulverized, and boiled for a long time with dilute nitric acid, which dissolved a large amount of magnesia with disengagement of carbonic acid; the solution contained besides, magnesia, iron, manganese and a trace of nickel, but no lime. The undissolved residue was then boiled with a solution of carbonate of soda, which took up a considerable amount of silica derived from the silicate which had been partially decomposed by the nitric acid, and left a dense granular matter mingled with silvery

scales of greenish talc, which were in great part removed by washing. The denser silicate was then dried at 250° F., and submitted to analysis. By ignition it lost 11·40 per cent. and then gave to a boiling solution of nitrate of ammonia a quantity of magnesia equal to 1·21 of carbonate. Another portion was decomposed by sulphuric acid, and the silica separated from the insoluble talc by a solution of carbonate of soda. The results of the analysis were as follows :—

Silica,	39·60
Magnesia,	36·72
Protoxyd of iron,	4·86
Oxyd of nickel,	(traces.)
Talc,	6·80
Water,	10·77
Carbonic acid,	·63
	99·38

Deducting the talc, the carbonic acid, and the amount of magnesia required to form with it 1·21 of carbonate, we have for the composition of this silicate dried at 250° F. :—

Silica,	43·34
Magnesia,	39·55
Protoxyd of iron,	5·32
Oxyd of nickel,	(traces.)
Water,	11.79
	100·00

This is the composition of serpentine, and the ophiolite of Roxbury is thus shown to consist of serpentine and talc, intermixed with a ferriferous carbonate of magnesia; the compact asbestus of Dr. Hayes is nothing more than serpentine.

9. *Diallage Rock.*—Associated with the ophiolites, throughout the Eastern Townships, there are found in abundance, interstratified masses of rocks, made up chiefly of diallage and actynolite. The township of Orford furnishes fine varieties of diallage rock, one of which, from the fifteenth lot of the thirteenth range, is the subject of the present examination. It consists in great part of a celandine-green, translucent diallage, the cleavage surfaces of which are sometimes half

an inch in breadth, and have a pearly sub-metallic lustre. The interstices between the masses of diallage are filled with a soft amorphous matter, varying from light to dark-green in colour, and resembling chlorite in its aspect. The rock is exceedingly tough, and weathers superficially reddish-brown.

Carefully selected cleavable portions of the diallage had a hardness of 5·0, and a density of 3·02—3·03; they contained intermixed grains of magnetic iron, which after the mineral had been reduced to powder, and suspended in water, was removed by a magnet, and equalled 4·37 per cent. Two analysis were made of different portions of the diallage thus purified; in the first the mineral had previously been digested with warm dilute nitric acid, which had however, no action upon it. This diallage, like the serpentines, loses all its water by calcination over a spirit-lamp, and then becomes very red from the peroxydation of the iron :—

	I.	II.		Oxygen.
Silica,	47·20	47·10	=	24·90
Magnesia,	24·53	24·58	"	10.01
Protoxyd of iron,	8·91	8·55	"	1·89
Oxyd of nickel, (traces.)	....	....		....
" " chrome, "	....	....		....
Alumina,	3·40	3·50	"	1·63
Lime,	11·36	11·34	"	3·24
Water,	5·80	5·85	"	5·20
	101·20	100·92		

This mineral differs from ordinary diallage in the great excess of bases, and the large amount of water which it contains. Further analysis are required to show whether this composition is constant, or belongs to the diallage in its pure state.

The mass of the rock, consisting of diallage intermixed with magnetite and with the amorphous mineral, gave the following results on analysis ;—

Silica,	41·80
Magnesia	26·13
Protoxyd of iron,	11·05
Oxyd of nickel,	(traces)
" chrome,	"

Alumina,	6·80
Lime,	7·00
Water,	7·60
	100·38

The material subjected to the above analysis had been digested for some minutes with warm dilute nitric acid, which removed insignificant traces of alumina, iron, lime and magnesia, but no nickel; the presence of which, and the absence of cobalt, was clearly established in the three analyses just given. The separated magnetite yielded no trace of chrome, though the diallage contains some thousandths of this element. From the last analysis it is evident that the intermixed mineral contains little or no lime, but more water and alumina than the diallage, and probably approaches to chlorite or pyrosclerite in its composition.

10. A diallage rock from the vicinity of the chromic iron ore-bed, in Ham, is made up almost entirely of a pale bronze coloured diallage, which sometimes exhibits cleavages two inches in length. An analysis of it gave the following results; chrome and nickel were not sought for in this specimen:—

Silica,	50·00
Magnesia,	27·17
Protoxyd of iron,	13·59
Lime,	3·80
Water,	6·30
	100·86

11. An actynolite rock from St. François (Beauce), was examined; it is exceedingly tough, and made up of interlacing fibres of actynolite, without any apparent intermixture; color within, dark greyish-green, but weathers nearly white. Its analysis gave:—

Silica,	52·30
Magnesia,	21·50
Protoxyd of iron,	6·75
Oxyd of nickel,	(traces)
Alumina,	1·30
Lime,	15·00
Water,	3·10
	99·95

12. An almost opaque greyish-green rock, resembling a serpentine, from the twentieth lot of the first range of Ireland, has been described in my Report for 1851. It had a density of 2·65, and gave by analysis :—

Silica,	43·70
Magnesia,	23·46
Alumina, Peroxyd of iron,	23·00
Water,	11·57
	101·73

From the absence of lime and the large amount of alumina, this substance may perhaps be regarded as an impure mixture of serpentine with an aluminous silicate, such as chlorite or pyrosclerite. Its analysis is only interesting as showing the very variable composition of the magnesian rocks of this series.

13. *Talc.*—This species frequently occurs in the series of rocks now under consideration, sometimes in pale green, foliated, crystalline masses; more frequently however, a massive schistose variety is met with, forming beds of steatite, which are sometimes interstratified with ophiolites, and at other times with clay slates. The beds of talc sometimes contain crystals of actynolite, or inclose crystalline masses of carbonate of magnesia, containing carbonate of iron and a little nickel.

A bed of steatite, on the sixteenth lot of the fifth range of Potton, which has afforded large blocks of excellent quality, was examined. It is greenish-white in colour, translucent, and occurs in slaty masses; when triturated in a mortar it shews a foliated structure; ignited over a spirit-lamp, it loses 3·70 per cent. of water, but at a white heat, 4·40 per cent. Its analysis by fusion with carbonate of soda gave as follows. It contained no trace of lime :—

Silica,	59·50
Magnesia,	29·15
Protoxyd of iron,	4·50
Oxyd of nickel,	(traces.)
Alumina,	·40
Loss by ignition,	4·40
	97·95

14. A soft silvery-white exfoliating talcose schist, from the twentieth lot of the fifth range of Potton, after being dried at 212° F., lost 3·0 per cent. by igniting over a spirit-lamp, and 3·6 per cent. by the heat of a furnace. The ignited mineral yielded nothing to a boiling solution of nitrate of ammonia. Its analysis was effected by fusion with carbonate of soda, and the absence of chrome and manganese was shown. The results were as follows :—

Silica,	51·50
Magnesia,	22·36
Protoxyd of iron,	7·38
Oxyd of nickel,	(traces.)
Lime,	11·25
Alumina,	3·50
Water,	3·60
	99·59

From the analysis, it appears probable that this material consists of a mixture of talc with some anhydrous silicate containing lime, perhaps a hornblende.

15. *Chlorite.*—This mineral species is abundant in the altered rocks of the series under consideration, sometimes intermingled with grains of quartz and felspathic matters, forming chloritic sandstones and schists, which frequently contain epidote, and magnetic and specular iron ores; the latter are often met with distinctly crystallized, sometimes with rutile, in chlorite slate, or in a chloritic dolomite. At other times, massive beds of slaty chlorite or potstone are met with, which being free from harder minerals, may be sawn and wrought with great facility. A rock of this description from the twenty-sixth lot of the sixth range of Potton, was of a pale greenish-gray colour, unctuous to the touch, and composed of lamellæ of chlorite, arranged in such a way as to give a schistose structure to the mass. Its analysis gave me :—

Silica,	29·60
Magnesia,	25·95
Protoxyd of iron,	14·49
Alumina,	19·70
Water,	11·30
	101·04

This is the composition of a true chlorite. Another portion of this rock furnished to Mr. Delesse, by a partial analysis: silica 29·88, water 11·50, lime 0·77; the alumina, oxyd of iron and magnesia not being determined. He found also a small portion of chrome, whose presence in some other specimens of the chloritic rocks of this region, is indicated in the Report for 1847.

16. In my Report for 1854 I had occasion to show that many of the so-called talcose slates owe their peculiar characters to a hydrous silicate of alumina, allied to pholerite or pyrophyllite, or to a hydrous mica, and the following analysis of a rock which had been wrought as potstone in the township of Shipton, is a case in point. It had a greenish-gray colour, somewhat lighter than the chlorite just described, than which it is finer-grained, and less schistose. It appears to be made up of minute shining scales, confusedly arranged, and its powder is not unctuous to the touch. Its analysis gave:—

Silica,	51·50
Alumina,	29·20
Protoxyd of iron,	9·27
Magnesia,	1·08
Potash,	1·54
Soda,	1·59
Water,	5·10
	99·28

This aluminous silicate differs from the micas in the presence of water, and in the small quantity of alkalies which enters into its composition. It contains neither lime nor nickel, but traces of manganese.

17. *Garnet Rock.*—The ophiolites, talcs and actynolites which we have already described, are essentially silicates of earthy protoxyd bases, while in diallage and chlorite these bases are associated with alumina. Two other minerals, which are double silicates of lime and alumina, are conspicuous among the rocks of this metamorphic series; they are epidote and garnet. The former characterises great masses of chloritic rock, although it is seldom well crystallized, or in a state of purity; but a peculiar white garnet occasionally forms a rock by itself, and merits a particular description.

A remarkable locality of this mineral is found in contact with an ophiolite on the sixteenth lot of the sixteenth range of Orford. The rock resembles some of the so-called serpentinous euphotides, and consists of a white garnet, having the aspect of saussurite, intermingled with a small amount of a soft green serpentine, which fills the interstices between irregular rounded masses of the garnet; portions of this mineral in a state of purity, are easily obtained half-an-inch in diameter. It is at once distinguished by a hardness of 7·0, and by its density, which for selected fragments, was found to be 3·522—3·536. It is amorphous, finely granular, and extremely tenacious, with a conchoidal fracture; lustre feeble, waxy; colour yellowish or greenish-white; sub-translucent. After intense ignition, which did not however effect its fusion, the pulverized mineral gelatinized with hydrochloric acid. Its analysis was made after fusion with carbonate of soda, and gave:—

	I.	II.
Silica,	38·60	38·80
Alumina,	22·71	
Lime,	34·83	
Magnesia,	·49	
Oxyds of iron and manganese,	1·60	
Soda and a trace of potash,	·47	
Loss by ignition,	1·10	
	99·80	

This mineral agrees closely in composition and properties with lime-garnet, whose theoretical composition is represented by silica 40·1, alumina 22·7, lime 37·2,=100·0. Croft obtained for a white garnet from the Ural Mountains, having a density of 3·504: silica 36·86, alumina 24·90, lime 37·15,=98·10.

18. A similar silicate is also found at the Falls of the River Guillaume, in St. François (Beauce, where it appears as a bed in contact with serpentine, and forms an exceedingly tough homogeneous rock, which has a hardness of 7·0, and scratches deeply the surface of agate; its density was found

to be 3·333—3·364. The rock has a sub-conchoidal fracture, with traces of crystallization; lustre shining, somewhat silky; colour yellowish-white; sub-translucent. It also occurs at the same locality as a greenish or greyish-white, somewhat granular rock, cavities in which are lined with small indistinct crystals; the density of this variety was 3·397—3·436.

Other specimens from the same locality exhibit the garnet intermingled with large cleavable masses of dark-green hornblende, which passes into a pearl-grey or lavender-grey variety. Small fragments of the garnet from this mixture had a density of 3·496; they were white, opaque, with a conchoidal fracture, and somewhat vitreous lustre. Intermingled with the garnet and hornblende, was another white or yellowish-white amorphous mineral, with a waxy lustre and a hardness of 6·0; the density of a nearly pure specimen of it was 2·729, of another 2·823. This, conjoined with its hardness, renders it probable that it is a felspar; but it is very difficult to separate it from the garnet, or even to distinguish between the two species by the eye alone. Another specimen of a white granular rock from the same locality, which had been taken for garnet, had a density of only 2·800, and was supposed to be chiefly felspathic in its nature. The specific gravity of the greyish hornblende was 3·046.

A specimen having a density of 3·333 was selected for analysis; its powder did not effervesce with heated nitric acid, which however dissolved from it considerable alumina and lime. By the ignition of the rock, its yellowish colour was only changed by the appearance of rare points of blackish-green. The analysis gave as follows:—

			Oxygen.
Silica,	44·85	=	23·69
Alumina,	10·76	=	5·03
Peroxyd of iron,	3·20	=	·96
Lime,	34·38	=	9·77
Magnesia	5·24	=	2·09
Loss by ignition,	1·10		
	99·53		

If we regard the alumina, the peroxyd of iron, and a portion of lime, as forming a garnet with the formula $Si^2,(al\ fe)Ca,O^4$, the residual lime and silica, with the magnesia, are in the proportions requisite to form a pyroxene, $Si^2,(CaMg,)O^3$. In these formulæ we have represented silica by SiO, while alO and feO correspond to these sesquioxyds with one-third their ordinary equivalent, thus: $Al^2O = 3\ alO$. We have for the garnet :—

			Oxygen.	
Silica,	22·69	=	11·98	= 2
Alumina,	10·76	=	5·99	= 1
Peroxyd of iron,	3·20			
Lime,	21·07	=	5·99	= 1
	57·72			

For the pyroxene there remains :—

			Oxygen.	
Silica,	22·16	=	11·71	= 2
Lime,	13·31	=	5·87	= 1
Magnesia,	5·24			
	40·71			

The rock just described will, according to this calculation, consist of garnet 57.72, and pyroxene 40·71, which, with 1·10 of volatile matter, make up the sum of 99·53.

Felspathic Rocks.

In the Report for 1854, I have described at some length a class of stratified felspathic rocks, which form an important part of the Laurentian series, and are associated with the calcareous and magnesian deposits of that ancient formation. These rocks are essentially composed of felspars of the triclinic system, generally associated with pyroxene, which passes into the variety hypersthene, and containing as accidental minerals, mica, garnet and ilmenite. The felspars, which contain lime and soda. with a small amount of potash, vary in composition

from bytownite, a variety approaching anorthite, to labrador felspar and andesine. These rocks are sometimes coarsely crystalline, at others porphyritic, or finely granular, passing into aphanite. The pyroxene is rarely in large quantity, and often wanting in a coarsely crystalline variety of the rock, which is the *labradorite* of d'Halloy, while others correspond to his *hypersthenite*, the *hyperite* of some other authors.

Various names have been employed to designate the different rocks which are essentially composed of felspars with pyroxene or hornblende. When the pyroxene is of the variety called augite, the rock is known as *dolerite;* it becomes *hyperite* when the pyroxene assumes the form of hypersthene, and takes the name of *euphotide* when the felspar, which is then generally compact (saussurite), contains the varieties of pyroxene known as smaragdite or diallage. In the euphotide of Corsica, according to Rose, the diallage, with the external form of pyroxene, has the cleavage of hornblende, constituting the variety uralite. In the euphotides of Baste and Veltlin, hornblende is associated with the diallage, and predominates over it at the latter locality, often replacing the diallage entirely, and giving rise to a rock composed of felspar and hornblende, which is the composition of what is called *diorite* or *diabase.*

When the elements of these compound rocks become so intimately mingled that the mass appears homogenous, the name of *aphanite* is given to it. This is the *cornean* or corneous rock of Brongniart, so called from its somewhat horny aspect. The various rocks which we have just mentioned, are in great part altered sedimentary strata, but some of them appear likewise as intrusive masses; the greenstones, traps and basalts of geologists, are either diorites or dolerites. These explanations will serve to prevent confusion for the future, in speaking of these felspathic rocks, which it will be seen pass insensibly into one another.

Associated with the ophiolites of the Silurian series, we have a very abundant rock, consisting of felspar intimately mixed with a silicate having the composition of a hornblende or pyroxene, and forming an aggregate scarcely to be distin-

guished from the finer grained varieties of similar rocks met with in the Laurentian series. This felspathic rock, in the Silurian series, is generally greenish or greyish-white, and more or less fine grained; occasionally however the hornblende is apparent in distinctly cleavable grains, forming a well characterized diorite; but it is more frequently pale in colour, and so disseminated as to give to the rock at first sight an almost homogeneous aspect, entitling it to the name of aphanite. These rocks weather of an opaque white, which is characteristic.

19. A variety of this diorite was examined from Brompton Lake, in the second lot of the sixteenth range of Orford; its colour is white, with a tinge of greenish or yellowish-grey, evidently due to the presence of an amorphous disseminated mineral, which becomes yellowish-brown after ignition, while the base is rendered white and more opaque, and is seen to consist of grains of crystalline felspar, sometimes with very distinctly striated cleavage plains. The rock before ignition has a waxy lustre, is sub-translucent, and has a sub-conchoidal fracture; its hardness is 6·0, that of ordinary felspar, and its density 2·748—2·764. Its powder does not effervesce with nitric acid, which appears to be be without action upon it. Its analysis was effected by fusion with carbonate of soda, and the alkalies were determined by decomposing a separate portion with carbonate of lime and sal-ammoniac; the results were as follows:

	I.	II.		Oxygen.	
Silica,	63·60	63·40	=	....	33·53
Alumina,	.....	12·70	=	....	5·93
Soda,	.....	7·95	=	....	2·06
Potash,	.....	·13			
Lime,	7·28	7·50	=	2·13	4·38
Magnesia,	.....	3·37	=	1·31	
Protoxyd of iron,	.....	4·23	=	·94	
Loss by ignition,	.....	·40			
		99·68			

The oxygen ratios of the alkalies and the alumina are very nearly as 1 : 3; and if we add to these the silica corresponding

to 12 equivalents, or in round numbers to 24·00 of oxygen, (equal to 43·20 of silica); we have the composition of albite, in which species the oxygen ratios of the silica, alumina and alkalies are as 12 : 3 : 1. There will then remain of the oxygen of the silica, 9·53, which is to 4·38, the sum of the oxygen of the lime, magnesia and iron-oxyd, very nearly as 9 : 4, the ratio of hornblende; the rock then consists of 64·0 parts of albite, and 35·3 parts of hornblende.

20. Another specimen of a similar rock from St. François (Beauce), was rather more coarsely crystalline than the last, and had a pale bluish-green colour, from the presence of an imperfectly crystalline hornblende, which is abundantly disseminated among the grains of a somewhat translucent cleavable felspar. The hornblende turns dark olive-brown by ignition, and the structure of the rock is then very evident; its lustre is feeble and waxy, and its density was found to be from 2·708 to 2·725; the pulverized rock yields to dilute nitric acid, a trace of alumina and a little lime. Its analysis gave me:—

			Oxygen.	
Silica,	63·60	=	33·95	
Alumina,	14·20	=	6·63	
Soda,	5·09	=	1·31	2·01
Potash,	4·13	=	·70	
Lime,	4·37	=	1·22	
Magnesia,	6·84	=	2·73	
Protoxyd of iron,	1·92	=	·43	
Loss by ignition,	·70			
	100·85			

If we regard the whole of alumina as representing the felspar, we find that the oxygen of the alkalies does not equal one-third of that of the sesqui-oxyd; and we must therefore suppose that a portion of lime equal to 0·20 of oxygen, enters into the composition of the felspar. We shall then have for the oxygen ratios; silica 26·52, alumina 6·63, alkalies (2·01 + 0·20), = 2·21, or 12 : 3 : 1. The oxygen of the silica to that of the remaining bases, will then be as 7·43 : 4·18; the hornblende ratio of 9 : 4, requires 3·30, and that of pyroxene

2 : 1, demands 3·71 of protoxyd. The slight excess is explained by the fact that there is a gain in the analysis, probably due to an error in the determination of the magnesia; besides which a little lime apparently exists in the rock as a carbonate. We have then for the felspathic portion of this diorite, 49·68 parts of silica, together with the alumina, alkalies, and 0·71 of lime, combined to form 73·81 parts of a felspar, which has the formula of albite, but is distinguished from that of the previous specimen, by the large proportion of potash which it contains.

Euphotide.—Much confusion exists among mineralogical writers as to the nature and characters of *saussurite,* a mineral, which mingled with smaragdite, constitutes the rock to which Haüy applied the name of *euphotide* De Saussure (senior), who first distinguished under the name of *jade,* the mineral which afterwards received his name, describes it as greenish-white in colour, sufficiently hard to scratch quartz, and having a density of 3·310—3·319; while Mohs gives 3·256 for the specific gravity of a granular variety from Piedmont, and 3·342 for a compact saussurite from the Canton de Vaud. Naumann assigns to the species a density of 3·40.

The earlier analyses of saussurite appear to correspond to impure felspathic mixtures; that examined by Stromeyer has the composition of labradorite, to which species the saussurite from the euphotide of Odern, examined by Delesse, belongs; it gave him: silica 55·23, alumina 24·24, lime 6·86, soda 4·83, potash 3·03, oxyd of iron 1·11, magnesia 1·48, volatile matters 3·05,=99·83. The saussurite of Mount Genèvre, (Hautes Alpes), is according to Delesse a crystalline felspar, containing silica 49·73, lime 11·18, soda and a little potash 4·28, besides 3·75 of water and carbonic acid; while that from the euphotide of Levaldens, (Isère) according to Lory is a cleavable felspar, having the composition of andesine.

These observers have for the most part neglected to record the density of the specimens which they have examined, although Delesse remarks that the specific gravity of the saussurites is seldom inferior to 2·80. Von Rath has recently described as saussurite, a white mineral which forms with

hornblende, (uralite) the greenstone of Neurode in Silesia, and possesses the hardnes, cleavage and crystallization of labradorite, with a density of 2·99. His analysis approaches closely to that from Mount Genèvre, but gives 2·73 per cent. of peroxyd of iron, evidently showing some admixture.

The saussurite from the Lizard, in Cornwall, examined by Thompson, has a hardness of 7·0, a density of 2·80, and contains 82·0 per cent of silica, besides alumina, lime, magnesia, and iron; it is apparently a petrosilex.

It is evident that all these felspathic minerals of low specific gravity are distinct from the saussurite described by de Saussure, which I imagine to have been nothing more than a white massive garnet, like that of Orford. This substance agrees in in hardness and density with the mineral described by de Saussure, and the aggregate of garnet and serpentine from Orford, (17) resembles completely some of the euphotides of Switzerland. The intimate manner in which the garnet is mingled with compact felspar and hornblende in the specimens from St. François, (19) will help to explain many of the discordant analyses and observations of previous authors.

The mixture of felspar and diallage which has generally received the name of euphotide, is on the contrary closely related to the diorites, such as we have described under 19 and 20, and is the *granitone* of the Tuscan geologists, improperly confounded by some writers with the *gabbro* of the Italians, which is a diallagic ophiolite, according to Brongniart and d'Halloy.

Petrosilex or Eurite.—Associated with the serpentines in the region under consideration, a peculiar rock is often met with, resembling those just described, but distinguished by being more homogeneous, more translucent, and by the absence of the opaque white coating on its weathered surfaces. A specimen of this rock from the sixth lot of the sixteenth range of Orford was examined. It was compact, very tough, and had a scaly conchoidal fracture. Color greenish or greyish-white; sub-translucent; lustre waxy, dull. It was apparently homogeneous, and had a hardness of 6·0, and a density of 2·635—2·639. Its analysis gave :—

	I.	II.
Silica,	78·40	77·70
Alumina,	11·81	
Soda,	4·42	
Potash,	1·93	
Lime,	·84	
Magnesia,	·77	
Protoxyd of iron,	·72	
Loss by ignition,	·90	
	99·79	

This rock differs chemically from those just described, by the large excess of silica, and the very small amounts of lime, magnesia and protoxyd of iron, which it contains. It is very similar in composition to the baulite or krablite from Iceland, and to some obsidians and pitchstones. It is the *compact felspar* of Haüy, the *petrosilex*, *eurite* and *adinole* of other authors. These rocks in the present state of our knowledge, may be considered as intimate mixtures of felspar with quartz, although the krablite occurs, according to Von Walterhausen, in distinct triclinic crystals.

Rocks of this composition are not, however, confined to the metamorphic portion of the Silurian series. I found at St. Henri, beds of compact felspar interstratified with the unaltered argillaceous shales and bituminous limestones of the Quebec group. The greatest mass of this rock observed in the section near the falls of the Etchemin river, at St. Henri, is fifty feet in thickness, and is divided into layers of from two to twelve inches by films of interposed shale, sometimes bright green in color. This is succeeded by a smaller mass of the same rock fifteen feet in thickness, the whole interstratified with greenish and greyish shales. Thin beds of a like substance are also met with at St. Anselme, in a similar series.

The rock is finely granular, sub-conchoidal in fracture, tough, and translucent on the edges; in colour is pale greenish-white, sometimes verging upon olive-green, and varied by clouds of darker green. The rock is singularly uniform in its characters, and has a great resemblance to the petrosilex from Orford, just described, but is somewhat less compact and

tenacious. Its hardness is 6. A specimen from St. Henri, gave the following results on analysis :—

Silica,	71·40
Alumina,	13·60
Soda,	3·31
Potash,	2·37
Lime,	·84
Magnesia,	2·40
Protoxyd of iron,	3·24
Loss on ignition,	2·50
	99·66

We find in these various felspathic rocks, which are evidently of sedimentary origin, but small amounts of oxyd of iron, varying from less than one, to three and four per cent., quantities much less than are found in ordinary felspathic or argillaceous sediments of this and other formations. It is well known that water dissolves protoxyd of iron when combined with carbonic or organic acids, and we have in waters holding dissolved organic matters, an agent which is constantly removing this metal from the superficial strata, and depositing it again in the forms of ochre and limonite. To a similar process we must ascribe the absence of iron from the under-clay of coal-beds, which, as you have shown, is but the soil of the ancient carboniferous vegetation, and from the felspathic rocks now under consideration. This metal has been dissolved out from the sediments by action of organic substances, and is found accumulated in the clay ironstones of the coal formation, and in the highly ferruginous schists of the Quebec group, which often contain beds of iron ore.

The upper part of the Richelieu shales, a little above Cap Rouge, presents two remarkable beds of a homogeneous jasper-like rock, sharply conchoidal in fracture, translucent on the edges, and in some parts so hard as to resist steel. Its colour varies from dark grass-green to blackish-green. The beds, which are six or eight feet in thickness, are traversed by veins calcareous spar, and are interstratified a few feet from each

other, with the shales of the region, which are contorted, but not at all altered. The same green chert or jasper is met with among the graptolitic shales at St. Henri, near the felspathic beds just described, and is also seen among the altered rocks of this group near the ophiolites, as at St. François (Beauce), and the Owl's Head mountain, itself having undergone but very little apparent alteration. It weathers opaque white. The density of a specimen from Cap Rouge was 2·640, and from St. Henri 2·662. The results of two analyses of the chert from Cap Rouge are as follows, I being the lower band, and II the upper band :—

	I.		II.
Silica,	77·50		73·30
Alumina,	8·50	Iron as peroxyd	16·30
Protoxyd of iron,	2·70		
Lime,	·73		traces
Magnesia,	2·35		3·90
Soda,	1·38		....
Potash,	1·66		....
Loss by ignition,	4·40		3·80
	99·20		

This rock is but slightly attacked by acids. On boiling a portion of I, for an hour, with a dilute solution of caustic soda, an amount of silica equal to 20·8 per cent was dissolved, but only 1·2 per cent of alumina ; this would appear to indicate the presence of a large amount of silica in its soluble modification. The petrosilex of St. Henri gave to a solution of soda by a similar treatment, only 6·1 per cent. of silica, and a few thousandths of alumina.

You have described a bed of red and green jasper which exists at Rivière Ouelle, in the slates of the Sillery group, and resembles the rock of Cap Rouge just described; it contains veins of calcedony, and the red colour of certain portions of it appears to be due to disseminated hematite. Near Sherbrooke there is a bed of red jasper, which contains grains of hematite, and passes into a jaspery-red iron ore. These rocks require a particular study.

Magnesites and Dolomites.

The existence of beds of carbonate of magnesia among the Silurian strata in the townships of Bolton and Sutton was noticed in the Report for 1847, and partial analyses of these rocks have been since given. I have however recently made these remarkable masses the subject of a more detailed examination, the results of which are here presented.

1. Associated with the dolomites and steatites of the twelfth lot of the seventh range of Sutton, there occurs a bed about twelve inches in thickness, made up of white crystalline magnesite spar, intermingled with grains of a felspathic mineral, and scales of bright green talc, which predominates in certain planes, and gives to the bed a gnessoid structure coincident with the stratification; small grains of pyrites are disseminated through the mass. On the weathered surfaces, the bright green colour of the rock is obscured by a rusty brown hue, due to the oxydation of a portion of carbonate of iron, which is combined with the carbonate of magnesia.

The composition of this rock varies in different layers, not only in the amount of insoluble silicious matters, but in the proportions of the two carbonates. A pure, slightly coloured portion, gave of carbonate of magnesia 83·35, carbonate of iron 9·02, insoluble 8·03, = 100·40; the analysis of another fragment afforded carbonate of magnesia 33·00, carbonate of iron 19·35, alumina 0·50, insoluble matters 45·90, = 98·70.

A small proportion of iron in the last analysis is however derived from the disseminated pyrites, which is nickeliferous; sulphur separates during the solution of the mineral in nitric acid, and the liquid then contains a little nickel; but when hydrochloric acid is employed as the solvent, the nickel is found with the residue. The insoluble portion has a fine pale-green colour, and when thoroughly purified from iron, by digestion with nitric acid, preserved its tint after ignition, during which process it lost 5·66 per cent.; after this operation it gave to a boiling solution of nitrate of ammonia a minute trace of magnesia. The analysis of a specimen which had been purified by nitric acid and ignited, gave (A) silica

50·25, alumina 36·88, magnesia 1·12, oxyds of iron and chrome 0·87, alkalies and loss 10·88, = 100·00.

The analysis of the residue left from the treatment of another portion of the rock by hydrochloric acid, gave the result B:—

	B.	C.
Silica,	43·30	52·17
Alumina,	32·10	38·67
Magnesia,	5·40	1·81
Protoxyd of iron,	5·90	
Oxyd of nickel,	·55	
" " chrome,	(traces.)	
Soda,	5·00	6·03
Potash,	1·09	1·32
Soluble matters,	7·50	
	100·84	100·00

The presence of a portion of carbonates in this residue was evident from the amounts of magnesia and iron present, as well as from the brown colour which it assumed by ignition. The amount of the green chromiferous talc in the residue is very small, as is evident from the first analysis; and if, excluding from the second, (B) all but the silica, alumina and alkalies, and a little magnesia and oxyd of iron, we compare the calculated result C, with A, we obtain a pretty correct idea of the composition of the felspathic matter, which mingled with a little talc, and probably with some silicate of alumina, forms the silicious portion of this magnesite rock.

2. The magnesite of the seventeenth lot of the ninth range of Bolton, has a breadth of many yards, and resembles closely many crystalline limestones, being made up of brilliant cleavable grains of ferriferous carbonate of magnesia, of a bluish-grey colour, but sometimes nearly white; it contains irregularly distributed, a considerable proportion of grains of white hyaline quartz, which sometimes forms small irregular veins. Many parts of the rock are marked by yellowish-green stains, due to a compound of nickel, which is probably a hydro-carbonate allied to the pennite of Hermann, and sometimes forms thin incrustations in the joints of the rock. The rock, which is strongly coherent, weathers superficially reddish-brown, from

the oxydation of the carbonate of iron. It contains a little oxyd of chrome and a small amount of pyrites.

The results of two analyses of different portions of the rock are as follows:—

	I.	II.
Carbonate of magnesia,	59·13	59·72
" " iron,	8·32	10·31
Insoluble,	32·20	29·90
	99·65	99·93

This rock, like that of Sutton, contains a variable amount of carbonate of iron. Another specimen analysed by Mr. Delesse of Paris, gave him carbonate of magnesia 58·59, carbonate of iron 9·06, quartz 30·12, lime and oxyd of chrome traces, water and loss 2·53.

The insoluble residue from the action of acids upon the Bolton magnesite, unlike that from Sutton, consists chiefly of quartz, as is evident from its reactions before the blow-pipe. A portion which had been twice digested with nitric acid, lost but 0·5 per cent by ignition, and had then a greenish-grey colour; fused with carbonate of soda, it gave 93·6 per cent. of pure silica, and 3·3 per cent. of alumina, with a little oxyd of iron and chrome, and traces of lime and magnesia, besides 0·8 per cent. of potash and soda. The nickel separated from several pounds of the rock was equal to about one-thousandth, and gave no indications of cobalt.

When calcined over a spirit-lamp, with access of air, the specimen II. lost 34·20 per cent.; 59·72 parts of carbonate of magnesia contain 31·28 of carbonic acid, and if to this we add 3·21, the difference between 10·31, the amount of carbonate of iron, and 7·10, that of the corresponding peroxyd, we have 34·49, which agrees closely with the above determination, and shows that the carbonic acid of the magnesite is completely expelled at a red heat. The ignited residue expelled ammonia from a boiling solution of nitrate of ammonia, which dissolved a portion of magnesia equal to 57·03 per cent. of carbonate.

The calcination of the rock is more easily effected than that of limestone, and yields a friable mass of caustic magnesia

and oxyd of iron, mixed with quartz; as this mixture will contain about 44 per cent. of magnesia, it may, as I have elsewhere suggested, be advantageously employed for the preparation of magnesian mortars. (Report for 1855, *ante* p. 422.) The calcined rock at once gives up its magnesia to a dilute acid, and may be economically made use of for the manufacture of magnesian salts. The iron is rendered nearly insoluble by the calcination, and the action of dilute sulphuric acid, the mineral being in excess, yields at once a solution of sulphate of magnesia, contaminated only by a little salt of nickel, which may be got rid of by the subsequent addition of a small portion of sulphuret of barium. In this way 100 parts of the calcined rock may be made to yield about 270 parts of crystallized sulphate of magnesia.

These crystalline carbonates of magnesia do not effervesce in the cold with nitric or hydrochloric acid, and require a prolonged digestion with these acids, aided by heat, for their complete solution. Acetic acid however decomposes them slowly at the boiling point; in this way two per cent. of carbonate of magnesia with a little oxyd of iron, were dissolved after fifteen minutes of ebullition. A solution of nitrate of ammonia also attacks pulverized magnesite; when that from Sutton was boiled for an hour with a solution of this salt, about two per cent. of the carbonate were dissolved, together with a notable portion of a protosalt of iron, from the decomposition of the carbonate of iron. The nickeliferous pyrites was not attacked, as was evident from the absence of nickel and sulphuric acid from the ammoniacal solution.

The existence of carbonate of magnesia in the form of rock masses has hitherto been but rarely observed; but it has probably often been confounded with dolomite. I have already described the ophiolite from Roxbury, Vermont, which is in large part composed of carbonate of magnesia, and among a collection of rocks brought from the gold region of California, by Mr. W. P. Blake of New York, I have detected a crystalline ferriferous carbonate of magnesia, mingled with quartz and films of emerald-green talc. The specimens resembled closely the rock from Bolton, and like it contained nickel and chrome.

Carbonate of magnesia also occurs in California as a compact porcelain-like rock, free from iron and silicious mixtures.

The dolomites of the Green Mountains resemble the magnesites in the mode of their occurrence, their aspect, and their associations, so much that it is only by analysis, or by their density, that it becomes possible to distinguish them. They generally contain besides carbonate of iron, traces of chrome and small amounts of nickel, which often stains the rock green, like the Bolton magnesite. This is conspicuous in a dark bluish-gray crystalline dolomite from the seventh lot of the twelfth concession of Windsor. The nickel is however sometimes wanting; thus a grey, crystalline, yellow-weathering, very ferruginous dolomite, which is interstratified with argillite, at the Falls of the Bras, in St. François (Beauce), gave me no trace of this metal, while a bed of steatite near to it, in the same series, is stained with nickel, and filled with crystalline grains, which are magnesite, without a trace of lime.

The magnesian rocks among the unaltered sediments of the Hudson River group afford an interesting study, which is as yet far from completed; but I beg leave to mention here a few facts which I have observed. The dolomites of Pointe Lévis, whose distribution you have followed out, are interstratified with the pure limestones, sandstones and graptolitic shales of the Quebec division of the Hudson River group. Both limestones and dolomites are very irregular and interrupted in their distribution, the beds sometimes attaining a considerable volume, while at other times they thin out, or appear to be replaced by sandstones.

The limestones frequently form masses of many feet in thickness, which are without any visible marks of stratification, and destitute of organic remains. These masses are compact, conchoidal in fracture, sub-translucent, and exhibit a banded agatized structure, which leads to the conclusion they are chemical deposits from water, in fact veritable travertines. Their colours are pearly-grey of different shades, and occasionally pale green; they weather smooth and white. Analysis shows that they are pure carbonate of lime, and contain neither silica, iron nor magnesia in appreciable quantities.

Interstratified with these travertines however, there are beds of fine granular opaque limestones, weathering bluish-grey, and holding in abundance remains of orthoceratites, trilobites and other fossils, which are replaced by a yellow-weathering dolomite.

The dolomites about to be described, occur both among the travertines and the fossiliferous limestones, sometimes in small lenticular masses, or in layers of a few lines, interposed in masses of limestone. At other times these layers of dolomites are several feet in thickness. They are always granular in texture, greyish within, and weathering reddish or yellowish-brown without. Unlike the intercalated limestones, which are generally free from mechanical impurities, the dolomites almost always contain a mixture of clay or sand, which sometimes so far predominates, that the rock is a friable dolomitic sandstone, whose fracture occasionally shows brilliant cleavage faces, thickly studded with grains of quartz, the carbonate having assumed a crystalline arrangment throughout the mass, as in the crystals of the Fontainebleau sandstone. No fossils have been detected in these dolomitic beds, which are sometimes traversed by veins of calcareous spar.

When dissolved in hydrochloric acid, the carbonic acid evolved from these dolomites has a bituminous odour, and the solution contains a considerable amount of iron as a protosalt. Of the following analyses, I is of fine-grained dolomite from the Island of Orleans, and II of a specimen from the lime-quarries near the church of St. Joseph at Pointe Lévis:—

	I.	II.
Carbonate of lime,	45·06	53·04
" magnesia,	31·81	31·96
" iron,	10·31	5·80
Insoluble,	13·80	8·80
	100·98	99·60

The insoluble portion from II was nearly pure quartz; that from I contained a portion of clay. The oxyd of iron from I was mixed with a little manganese, but neither chrome nor nickel were detected in these dolomites. Small masses of

pyrites which are found in the rock from Orleans, were likewise examined for nickel without success.

A bed of argillaceous rock from Pointe Lévis, which was compact, earthy in fracture, and weathered reddish-yellow to a considerable depth, gave to acids about fifty per cent. of soluble matter, corresponding to a ferriferous dolomite, like those just described. The insoluble residue was essentially a clay, containing about four per cent. of alkalies, of which two-thirds were potash.

Interstratified with these limestones and dolomites of Pointe Lévis, there are found beds of conglomerate of a remarkable character. In addition to sand and clay, the dolomites frequently enclose grains and rounded fragments of limestone and dolomite, both seemingly derived from the adjacent strata; so that we have beds consisting of pebbles of limestone, often having the characters of the travertine, of dolomite, and occasionally of quartz and argillite; the whole cemented by a ferriferous dolomite. At other times the cementing material of the conglomerate is a carbonate of lime, with only traces of magnesia and oxyd of iron; portions of the travertine itself sometimes inclose grains of quartzose sand.

ON THE PROBABLE ORIGIN OF DOLOMITES AND MAGNESITES.

The facts which we have indicated, clearly show that the dolomites just described have been precipitated from water, under conditions which brought more or less sand and clay, and sometimes fragments of the adjacent rocks, into the basins where this process was going on; during the intervals of which the travertines and fossiliferous limestones were deposited, to the exclusion of magnesia. Similar conditions are met with in some limestones of the Niagara division, in the eastern basin, where purely calcareous corals, of many species, are imbedded in a paste of granular magnesian carbonate of lime, which would seem to have been precipitated in the medium where the zoophytes grew. A somewhat different process is presented in the replacement by dolomite, of fossils in the limestone at Pointe Lévis, as well as at many localities

in the Chazy limestone, where various shells are replaced, and sometimes entirely filled, with a crystalline ferriferous dolomite, (Report for 1852, page 174,) the surrounding limestone being destitute of magnesia and iron.

The following considerations may aid us in forming an idea of the origin, hitherto so obscure, of magnesian deposits. It is known that those mineral waters which hold large quantities of carbonate of lime and magnesia in solution, deposit only the lime on exposure to the air, and retain all the magnesia in solution ; hence travertines and tufas, both ancient and modern, contain little or no magnesia. The carbonate of this base is soluble to a considerable extent, in solutions both of magnesian and alkaline salts, but is deposited when those solutions are boiled, or evaporated at low temperatures. Thus the alkaline waters of Carlsbad in Bohemia, which contain according to the analysis of Berzelius, seventeen parts of carbonate of lime for ten of carbonate of magnesia, deposit great masses of travertine, which is purely calcareous, but if suffered to evaporate in open basins, would afterwards yield dolomite or magnesite.

But besides these waters, which contain an excess of carbonic acid, and a larger amount of carbonate of lime than of magnesia, we meet with another class of saline mineral waters, which contain very little carbonic acid, and a small amount of carbonate of lime, but large portions of carbonate of magnesia. The mineral spring of Püllna, according to Struvé, contains in 1000 parts of water, 32·72 of solid matters, consisting entirely of sulphates and chlorids of magnesium and sodium, with 0·10 of carbonate of lime and 0·83 of carbonate of magnesia, and only seven-hundredths of its volume of carbonic acid. Waters of this kind appear, from the analyses of Berzelius and Struvé, to be rare in Germany, but are very numerous in this country,

The saline waters which in the western basin of Canada, rise from the lower limestones of the palæozoic rocks, have no excess of carbonic acid, and no appreciable amounts of earthy carbonates, but contain, besides common salt, great quantities of chlorids of magnesium and calcium, the latter in excess ; in this respect they differ from sea-water.

The saline springs rising from the same rocks farther east, are more dilute than the last, and contain, proportionably, a much less amount of earthy chlorids, that of magnesium always greatly predominating. They contain no excess of carbonic acid, but like the Püllna spring, hold in solution large amounts of carbonate of magnesia, and but very little carbonate of lime. I have elsewhere remarked that the substitution of these waters, for the brines which issue from the same strata farther west, is to be attributed to the action of the alkaline carbonates derived from the argillaceous sediments which occur in the Chazy limestone, and make up the great bulk of the Hudson River group. We also find in this region, saline springs containing carbonate of soda, and another class in which the amount of chlorid of sodium is very small, the carbonate of soda predominating. These springs appear to be derived from the argillaceous rocks, and by their admixtures with the brines, to have given rise both to the alkaline salines, and to the waters containing carbonate of magnesia. (Report for 1853, *ante* p. 348.)

The elimination of the greater part of the lime from the saline magnesian waters, is explained by the following experiment: a solution was prepared with eighty parts of common salt, eight of chlorid of calcium, a portion of crystallized hydrochlorate equal to about nine parts of chlorid of magnesium, and 1000 parts of water. To this liquid, at a temperature of 60° F., there was added a solution of carbonate of soda, sufficient to decompose about two-thirds of the earthy chlorids; the voluminous precipitate which was formed, became dense and granular after forty-eight hours, and after some days was separated, washed and analysed; it consisted of carbonate of lime, with 16 per cent of carbonate of magnesia. The saline liquid when evaporated at a gentle heat to one-twentieth, gave an abundant granular precipitate of the mixed carbonates, in the proportions of 16·3 of carbonate of lime to 83·7 of carbonate of magnesia; and the solution now contained abundance of magnesian chlorid, but not a trace of lime. On adding to this solution of chlorids of sodium and magnesium, diluted to its original volume, carbonate of soda enough to decompose about one-half of the latter, there is obtained a precipitate of carbonate of magnesia,

which becomes granular after a few days; and the liquid, by evaporation to one-twelfth, at a temperature below 212°, deposited a granular precipitate, which, in one experiment, corresponded to one and a-half parts of carbonate to 1000, or more than one-third of the magnesia in solution.

The mingling of alkaline carbonates with sea-water or saline springs of analogous constitution, effects then a partial separation of the lime from the magnesia, and gives rise to waters having a composition analogous to the Püllna spring, which by slow evaporation, or by a subsequent addition of carbonate of soda, may deposit carbonate of magnesia containing little or no lime. I subjoin some results of the analyses of different mineral waters of Canada, which serve to illustrate the question. The analyses will be found in detail in preceeding Reports; in this table the sum of the solid ingredients, and the amounts of the earthy chlorids, and alkaline and earthy carbonates, for 1000 parts are given; these waters are for the most part destitute of sulphates.

A, saline waters containing little or no earthy carbonates.

B, saline waters containg abundance of earthy carbonates.

a, neutral.

b, alkaline.

C, waters feebly saline, containing alkaline carbonates, borates, and silicates.

LOCALITIES.	SOLID MATTERS	CHLOR. CALCIUM	CHLOR. MAGNES.	CARB. SODA.	CARB. LIME.	CARB. MAGNES.
A, Whitby, ...	46·30	17·53	9·54	.....	0·	6
" Hallowell, ...	68·00	15·90	12·90	.....	.....	.....
" "	36·00	9·20	9·40	.....	.....	.....
B*a*, Caledonia, (V.).......	14.64	·28	1·03	.....	·12	·86
" St. Léon, ...	13·83	·07	·66	.....	·35	·94
" Caxton, ...	13·65	·05	·37	.....	·21	1·06
" Plantagenet, ...	13·16	·13	·24	.....	·03	·89
" Ste. Geneviève,.......	20·99	·60	2·05	.....	·01	·75
" Berthier,............	9·06	·04	·08	.....	·05	·83
B*b*, Varennes,...........	9·58	.....	.....	·32	·35	·35
" Fitzroy, ...	8·34	.....	.....	·59	·15	·78
" Caledonia, (I.)	7·75	.....	.....	·05	·15	·52
C, Chambly,...........	2·13	.....	.....	1·06	·04	·07
" Nicolet, ...	1·56	.....	.....	1·13	.....	....
" St. Ours, ...	·53	.....	.....	·13	·17	·13
" Jacques Cartier,......	·34	.....	.....	·19	·07	·03
" Joly,...............	·75	.....	.....	·23	·06	·02

Waters containing carbonate of soda are very abundant in nature; we may mention the celebrated mineral springs of Vichy, and those of Carlsbad, which latter discharge annually, according to the calculation of Gilbert, more than thirteen millions of pounds of carbonate of soda, besides sulphates and chlorids in still larger amount. The water obtained from the chalk beneath the clays of the London basin, by the artesian well in Trafalgar square, contains according to the analysis of Messrs. Abel and Rowney, 68·24 grains of solid matters to the imperial gallon, of which 18·05 grains are carbonate of soda, the rest being chlorids and sulphates of alkalies, with small amounts of phosphates and of earthy carbonates. (*De la Beche, Geological Observer*, p. 693.) This water is remarkable for its great proportion of potash salts, equalling 13·67 grains of sulphate of potash, and resembles in this respect the alkaline water of St. Ours, in which potash constitutes one-fourth of the alkaline bases. (Report for 1852, p. 158.)

The natron lakes of Lower Egypt are basins, fed by springs holding in solution common salt and carbonate of soda, and deposit by spontaneous evaporation large quantities of the latter salt, which under the name of *natron*, has been an article of commerce in Egypt from remote antiquity. The soda lakes of central Hungary are similar to those of Egypt, and furnish annually large quantities of carbonate of soda for consumption. Soda lakes also occur on the shores of the Black Sea, in northern Africa and in Columbia. Lake Van, which is situated on the western confines of Persia, has, according to de Chancourtois, an area of nearly 800 square miles, and its waters contain in 1000 parts, 22·6 of salts, of which 8·6 are carbonate of soda. If similar conditions of soil and of climate were met with in Canada, the springs of Chambly and Nicolet would give rise to natron lakes precisely like those of Egypt and Hungary. Rivero and Boussingault have described beds of the sesquicarbonate of soda, called *trona*, which occur in clays of the tertiary period near Lagunilla, in Columbia.

With such evidence of its distribution in nature, we cannot avoid the conclusion that the reaction between carbonate of soda, and the soluble salts of lime and magnesia which the sea

contains, must have played an important part in the production of sedimentary deposits, and given rise to many of our magnesian rocks. In the evaporation of sea-water we observe a phenomenon worthy of notice in this connection, which is that the lime which the water contains, is all precipitated in the form of gypsum, before the separation of common salt, so that the salt lakes of the Crimea and the basin of the Caspian, which are saturated with the chlorids of sodium and magnesium, contain no lime salts, but are true bitterns. This explains the frequent association of beds of gypsum with the rock-salt of ancient basins. When the mother liquors from sea-water are still further evaporated, sulphate of magnesia separates, and finally a double chlorid of potassium and magnesium, both of which salts occur native in the solid state.

The analyses of Deville and myself, among others, have shown that a great many river-waters contain small portions of carbonate of soda, which, together with the more strongly alkaline waters, must in the course of ages have diminished the quantity of lime salts in the sea-water, separating this base in the form of carbonate, to be precipitated as such, or secreted by animals, and we find that at the present day, magnesia greatly predominates over the lime in the ocean. 100 parts of the salts from the German Ocean contain 11·04 parts of chlorid of magnesium, and 5·15 of sulphate of magnesia, with only 4·72 of sulphate of lime, while in the waters which impregnate the palæozoic limestones, the salts of lime predominate over those of magnesia. Are we to look upon these waters as representing the composition of the sea at the time when these ancient strata were deposited, or suppose their composition to have been modified by subsequent reactions between the carbonate of lime and the magnesian salts? This is a question which I propose very soon to investigate.

Metals of Magnesian Rocks.

The various magnesian rocks which we have described from the Green Mountains, are distinguished by the presence of considerable amounts of protoxyd of iron, and smaller portions

of the rarer metals, chrome, titanium, nickel, and more rarely cobalt. Chrome and nickel, as we have seen, characterize the magnesites and dolomites, as well as the serpentines, talcs, dolomites, and diallages of the Eastern Townships. These two metals seem to be very generally present in the ophiolites of the Green Mountain range. I have found them in those of Roxbury, Vermont, New Haven, Connecticut, and Hoboken, New Jersey, as well as in an ophiolite and a magnesite from California, and in specimens of serpentine from Cornwall,* from Banffshire in Scotland, and the Vosges in France. Chromic iron, in fact, is peculiarly characteristic of serpentine rocks, in North America, the Shetland Isles, Norway, and in the department of the Var in France. Both nickel and chrome have besides been found by Hermann in the pyrosclerite of Pennsylvania, and by Brush in antigorite, a slaty serpentine from Piedmont, and williamsite, a serpentine from

* The ophiolites of Cornwall occur, according to De la Beche, among rocks of Devonian age. I have examined a clouded, reddish-brown and greenish serpentine, containing small grains of diallage, and said to be from the Lizard Point. It gave on analysis:—

Silica,	40·40
Magnesia by difference,	37·43
Protoxyd of iron and chrome,	7·47
Oxyd of nickel,	·15
Alumina,	·65
Loss on ignition,	13·90
	100·00

I have examined specimens of the following serpentines without detecting the presence of nickel:—

1. Pale greenish-yellow granular serpentine, from Easton, Pennsylvania, density 2·501.

2. Fine wax-yellow translucent serpentine, from Montville, New Jersey; it contains veins of beautiful yellowish-white chrysotile, which has a density of 2·435.

3. Pale olive-green serpentine, from Phillipstown, New York; contains no trace of chrome.

4. Pale-green serpentine from Modum, Norway, with ilmenite and magnetite; contains no chrome.

5. Yellowish-green serpentine, from Newburyport, Massachusetts; density 2·551; probably of Devonian age.—*Am. Jour. Science*, (II.) vol. xviii., p. 198.

Pennsylvania. The talcs and chrysolites of many foreign localities have also afforded small quantities of nickel to Stromeyer and others. Oxyd of cerium has been found in a serpentine by Lychnell, and vanadium by Ficinus in that of Zoblitz in Saxony, and in the bronzite of Genoa, by Schafhâutl.

The almost constant presence of these metals in magnesian rocks acquires a new significance when we consider, in connection with the view which I have advanced of the origin of these rocks, that nickel and cobalt have been found with titanium and glucina, in the ochreous deposit from the mineral spring of Neyrac, and in the water of this and several other chalybeates, and that nickel and cobalt, with chrome, have also been detected in the deposit from the alkaline waters of Carlsbad. Muller moreover found in a hydrated peroxyd of iron (limonite from Wurtemburg, small portions both of chrome and vanadium.

I have already noticed the presence of titanium in the Lower Silurian rocks, in some of the unaltered red ferruginous slates; as titanic iron or ilmenite in a serpentine from Beauce, and in the chloritic iron-schists, where it is also occasionally found in the forms of sphene and rutile. The analysis of an impure limestone, which contains at the same time magnesia, iron, manganese, titanium, chrome, and nickel, is therefore not without interest in this connection.

This remarkable rock occurs interstratified with the red and green shales, and sandstones of Granby, which appear to belong to the upper portion of the Hudson River group. The rocks are here disturbed, and upon the confines of the metamorphic region. The green sandstones, according to your description, (Report for 1847, p. 25,) are sometimes calcareous, and hold scales of chlorite, mica, and graphite; they frequently weather black from the presence of manganese. Other beds of these sandstones are red; they are sometimes conglomerate, and hold small pebbles of quartz and felspar, having the characters of an arkose. The red shales exhibit in one place a layer of titaniferous jaspery red iron ore; the green slates are chloritic, and associated with others greyish in colour, and with thin layers of a carbonàceous shale.

Among these shales you have described two beds of chloritic calcareous rock, of one foot and two feet in thickness; they weather to some depth of a chocolate brown, but have within, a dull greyish-green colour, and an earthy aspect. When moistened, the rock is seen to consist of a pale green base, in which are imbedded darker green scales of chlorite.

In the Report already cited, it has been said that this rock yields 30 per cent. of carbonate of lime, besides portions of magnesia, iron, chrome, and manganese. I have since submitted it to a farther examination. The rock in powder, effervesces strongly with acetic acid, and a little hydrochloric acid having been added towards the close of the operation, there were dissolved, carbonate of lime 30·08, magnesia, calculated as carbonate, 3·68, oxyd of iron and alumina 5·45, oxyd of manganese 0·58 = 39·76. The residue contained no lime, but the presence of chrome in it was again verified, and 0·15 per cent. of nickel were also found, besides a large amount of titanic acid, amounting in two determinations to 5·3 and 6·2 per cent. The analysis was effected by fusion with carbonate of soda, and gave for 100 parts of the residue insoluble in acetic acid:—

Silica,	53·20
Alumina,	7·90
Protoxyd of iron,	15·75
Magnesia,	8·79
Titanic acid,	6·30
Oxyd of nickel,	·15
Oxyds of chrome, manganese, and loss,	2·45
Soda and potash,	·66
Loss on ignition,	4·80
	100·00

Serpentine of Syracuse, New York.

There exists in the State of New York, a remarkable case of local metamorphism of the Onondaga salt group of the Upper Silurian rocks, which has resulted in the production of an ophiolite. As this group is largely developed in Western

Canada, and as the case has much interest in relation to the theory of metamorphism, I propose to give here a short notice of the rocks of the formation, and of the results of my examination of the ophiolite.

The lithological characters of the Onondaga salt group are as follows :—Reposing upon a curious concretionary limestone which belongs to the Niagara division, there is a series of very ferruginous shales, succeeded by others red and green in colour, which are calcareous. These are overlaid by the so-called gypseous marls, which include great masses of gypsum, arranged in layers, together with beds of cellular tufaceous limestone, and of a compact argillaceous dolomite, which is used for the fabrication of a hydraulic cement, and contains according to the analyses of Dr. Beck, from 30 to 38 per cent. of carbonate of magnesia, with from 10 to 20 per cent of silica, and portions of alumina and oxyd of iron. Similar cement-beds occur in the same formation in Western Canada, at Paris, and in Oneida, and yield as much as 40 per cent. of magnesian carbonate.

The marls of this series are filled with those well known hopper-shaped cavities, supposed to have been left by the solution of crystals of common salt, with which the waters issuing from these strata are strongly impregnated. Overlying these gypsiferous marls, is a limestone marked by curious needle-shaped cavities, which Mr. Vanuxem, to whom we owe this description, ascribes to the crystallization of sulphate of magnesia during the deposition of the rock. He remarks that we find in the succession of the gypsum and other salts in this formation, the evidences of conditions similar to those presented during the slow evaporation of sea-water.

At Syracuse, the strata between two beds of the porous limestones just described, are very much altered; the shales are rendered harder, and some portion of the calcareous rocks have become crystalline, and are filled with crystals of celestine and calcite, while other beds are converted into a calcareous ophiolite, a specimen of which I have examined. It agrees closely with the description given by Vanuxem, being an aggregate of grains and rounded masses of serpentine of various

sizes, imbedded in a greenish-gray calcareous base. The colours of the serpentine vary from blackish-green to greenish-white; it is often translucent, and takes a high polish. Small portions of bronze-coloured diallage are disseminated in the ophiolite. Mr. Vanuxem has also observed among these rocks, the existence of mica, in aggregates having the characters of granite, and others in which hornblende replaces the mica, and which he compares to syenite.

I found a portion of this ophiolite in powder, to be readily attacked by acetic acid, which dissolved a large amount of carbonate of lime, besides a little magnesia, and traces of alumina and iron. This proximate analysis gave: carbonate of lime 34·43, carbonate of magnesia 2·73, serpentine, insoluble in acetic acid, 62·50, iron and alumina 0·34 = 100·00. The analysis of the serpentine gave me:—

Silica,	40·67
Magnesia,	32·61
Protoxyd of iron,	8·12
Alumina,	5·13
Water,	12·77
	99·30

No traces of nickel or chrome were detected. A rounded fragment of greenish fine grained limestone, which was imbeded in this ophiolite, was found to be nearly pure carbonate of lime.

Mr. Vanuxem remarks of these metamorphic rocks of Syracuse, that we have here no evidence of igneous action, or of the intervention of a dry heat, which he supposes however to be often concerned in alterations of this kind; he suggests that water, aided by heat to produce the solution of the elements present, might give rise to the results there observed. (*Report on the Geology of the* 3*rd District of New York*, pages 108—110.)

ON THE METAMORPHISM OF SEDIMENTARY ROCKS.

The fact that sedimentary strata of different ages, may under certain circumstances, assume the characters which were for-

merly attributed to the primary rocks, having been once established, geologists sought to explain this alteration by the influence of heat, communicated through the medium of intrusive rocks, which was supposed to have produced a partial fusion and crystallization of the sediments. Boué, Silliman, Lyell and others, who have written upon this subject, conceive that for these changes a temperature of ignition has been required, aided probably by the presence of water, or aqueous vapour. But the presence of unoxydized carbon, as graphite, in various metamorphic rocks, which would oblige us to admit that this element had been submitted to a red heat in contact with water, with carbonates, and with oxyd of iron, leads us to reject this view as untenable. Graphite, like the other forms of carbon, is oxydized under all these conditions. The slight alterations suffered by many of the sediments in metamorphic regions, furnish us with other reasons for rejecting the idea of metamorphism at a very elevated temperature.

It is besides to be remarked that the igneous rocks, which are supposed by this hypothesis to be the source of heat, are often wanting in metamorphic regions, while on the other hand, their presence, although sometimes accompanied with a considerable extent of alteration, is frequently almost without effect on the adjacent strata. Numerous facts seem to show that the heat of igneous rocks extends to but very short distances in the non-conducting masses of sedimentary rocks.

These considerations, not less than the difficulty of conceiving an agency capable of heating to ignition immense masses of strata over large areas, lead us to reject alike the idea of an intense heat, or the proximity of igneous rocks, as the efficient cause of metamorphism. We are led to seek for an agent, which under conditions of temperature easily attainable, shall suffice for the production of these chemical changes which are required for the alteration of the sedimentary rocks. Such an agent we have in solutions of alkaline carbonates, which at a temperature of 212° F., lose a portion of their carbonic acid,* and acquire the power of dissolving silica,

* Jacquelain, *Ann. de Chimie et de Physique*, 3me série, tome xxxii., p. 211.

even in the form of quartz, forming with it a soluble alkaline silicate.

Kuhlmann, in his investigations of the soluble silicates, observed that carbonate of lime removes all the silica from a boiling solution of silicate of soda, forming an insoluble silicate of lime. Having moreover detected traces of alkalies in a great many natural silicates, other than those into whose composition these elements are supposed to enter, he suggested that alkaline silicates may have played an important part in the formation of these minerals.* Pursuing this idea, I have found that the carbonates of magnesia and protoxyd of iron possess a similar power of decomposing the soluble alkaline silicates, and that by boiling for some time with a solution of carbonate of soda, mixtures of these carbonates with silica, they were changed into silicates, which retained small portions of the alkali. This reaction takes place readily at 212° F. with ignited soluble silica, and although more slowly, even with pulverized quartz. The silicate of soda at first formed, is converted into carbonate by double decomposition, and is then free to dissolve a new portion of silica.

Recurring now to those sedimentary rocks which consist of carbonates of protoxyd bases, intermingled with silica, we have only to suppose them saturated with a solution of carbonate of soda, such as the water which impregnates the palæozoic schists of Canada, or the chalk of the London basin, and exposed to a heat of 212° F., and we have all the conditions required for the production of silicates of lime, magnesia and iron. The small portion of carbonate of soda acts as an intermedium between the silica and the bases, while at the same time the agency of the disengaged carbonic acid, in dissolving the carbonates, and bringing them in contact with the newly-formed alkaline silicate, is not to be overlooked. The presence of alumina in these sediments would furnish the element necessary for the production of garnet, epidote and chlorite.

But while some of these changes may take place at 212° F., it is probable that other phenomena of metamorphism may

* *Comptes Rendus de l'Académie des Sciences*, tome xli., p. 1029.

require a somewhat more elevated temperature. De Senarmont has shown that sulphate of baryta is dissolved when heated to 480° F., in a sealed tube, with a solution of bicarbonate of soda, and crystallizes unchanged on cooling.* It is probably by a similar process that felspathic and micaceous silicates have been crystallized during the metamorphism of sediments, often without obliterating the accompanying fossils.

A similar process must have given rise to the crystals of chiastolite, staurotide, and garnet, in the argillites and mica slates. That the silicate of magnesia has also been in solution, is evident from the veins of chrysotile and other varieties of serpentine which occur in the ophiolites. The layer of pure massive serpentine (retinalite,) with picrolite, which you have observed at Grenville, lining the walls of a trap dyke, in a calcareous ophiolite, is also a case in point. (Report for 1845, page 85.) Apparent evidences of a concretionary arrangement are sometimes met with in ophiolites, but the general resemblance between their structure, and that of the magnesites and dolomites which we have described, is obvious.

When the amount of alkaline salt is small, and the volume of sediment large, the process of metamorphism may find a limit in the fixation of the alkali, by the silicates which are formed. Apart from the small portions of it which thus enter into the silicates of magnesia and lime, it may perhaps combine with aluminous silicates to form felspathic and micaceous minerals; thus it will happen that portions of the strata, in regions of altered rocks, are sometimes found to have escaped the metamorphic process. This consideration enables us to understand why, in some cases, the influence of a mass of igneous rock has altered sedimentary strata to a considerable distance, these having contained the alkaline salt necessary to give solubility to the elements present, while those rocks in which the alkali was absent, have escaped change. The presence of soluble salts of lime or magnesia in a sediment, by neutralizing the alkali which might be infiltrated from other strata, would also prevent metamorphism.

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* *Expériences sur la formation des minéraux par la voie humide*, etc., *Ann. de Chimie et de Physique*, 3me série, tome xxxii., p. 129.

It how remains for us to inquire for the sources of the heat required to produce these changes. Local alterations are often caused by the injection of igneous rocks, and probably by thermal waters, which sometimes have a temperature of 212° at the surfaces, and doubtless surpass that degree at small depths. By such an agency we may explain the production of the ophiolites of Syracuse, and of similar localities in Europe, where we find masses of these magnesian silicates, often with gypsum and sea-salt, in rocks even of the tertiary period. But the alteration of the strata over wide areas, which are often free from igneous rocks, I conceive to be due to the heat of the earth's crust, which, as is well known, increases regularly as we descend, so that at a depth of 10,000 feet, it is calculated that the temperature must be equal to that of boiling water, and at 20,000 feet, to nearly 400° F.

It follows then from what we have said, that rocks covered by 10,000 feet or more of sediment, and permeated by alkaline waters, are in the conditions required for their alteration, and that elevation and denudation would exhibit these lower strata to us in the state of metamorphic crystalline rocks.

LAURENTIAN ROCKS.

Ophiolites.—The crystalline limestones and dolomites of this formation are occasionally associated with serpentine, which is sometimes disseminated in grains through them, or more rarely forms beds, in which the magnesian silicate greatly predominates. In the analyses given at page 366, we have seen that the dolomites of this series, unlike those of the Silurian rocks, contain very little oxyd of iron; and the same thing is true of the ophiolites. Hence the serpentines of the Laurentian series are paler in colour, and have a less specific gravity than those which we have already described. My examinations of them have not yet enabled me to detect the presence of either nickel or chrome, which characterize the magnesian rocks of so many other regions. The serpentines about to be described are more tender than those of the Green Mountains, and from their brittleness and pale colours, are less fitted for the purposes of

decoration; they also contain a larger amount of water, which may in part be hygroscopic.

The ophiolites of this series occasionally enclose small portions of mica and pyrites, and the calcareous ones sometimes contain sphene, and small crystals of phosphate of lime.

1. A calcareous ophiolite from Burgess, discovered by Dr. Wilson, is made up of a pale olive-green serpentine, somewhat crystalline in its texture, intermingled with a little magnesian carbonate of lime, which is sometimes white, and at other times reddish in colour. The rock contains besides, some crystals of a greenish-white mica, and disseminated pulverulent hematite, giving a red colour to portions of the mass. When reduced to powder, it gave to boiling acetic acid, 6·28 p. c. of carbonate of lime, and 3·27 p. c. of carbonate of magnesia. The insoluble residue lost by ignition 14·5 per cent., and then gave to a boiling solution of nitrate of ammonia, an amount of magnesia equal to 0·67 per cent. of carbonate, making a total of 3·94 p. c. of carbonate of magnesia. The pulverized rock, ignited without previous digestion in acetic acid, and boiled for a long time with nitrate of ammonia, yielded 5·90 per cent. of carbonate of lime and 3·84 of carbonate of magnesia, numbers agreeing with the preceding, while by the same process the unignited mineral gave 6·30 of carbonate of lime, and a large amount of magnesia.

The residue from the action of acetic acid, including however 0·67 per cent. of carbonate of magnesia, gave by analysis :—

Silica,	42·10
Magnesia,	38·94
Protoxyd of iron,	3·69
Loss by ignition,	14·50
	99·23

2. A dull reddish-brown ophiolite, from the same locality as the last, likewise contained a small amount of disseminated carbonates, which were completely removed by acetic acid. Thus purified, the matter gave on analysis :—

Silica,	39·80
Magnesia (by difference),	38·40
Protoxyd of iron,	7·92
Loss by ignition,	13·80
	100·00

The dark colour and opacity of this rock seem to be due to the presence of disseminated peroxyd of iron, to which some foreign ophiolites appear to owe their red colours.

3. A pale greenish-grey ophiolite, nearly opaque, soft, and earthy in its aspect, occurs at the Calumet Island, on the Ottawa, and being sought after by the Indians, who fashion the stone into calumets or pipes, has given the name to the Island. It contains no lime, but after ignition, yields a trace of magnesia to a solution of nitrate of ammonia. Its analysis showed a mixture of an argillaceous matter; it gave:—

Silica,	37·50
Magnesia,	37·58
Alumina and oxyd of iron,	9·00
Loss by ignition,	15·00
	99·08

4. A white lamellar dolomite from Grenville, which held abundance of honey-yellow grains of serpentine, was examined. Small fragments of the rock were digested with cold dilute nitric acid, and the carbonates being slowly dissolved, the grains of serpentine were liberated, and were found to be only slightly attacked upon their surfaces, which were rendered dull and opaque. The larger grains, some of which were one-tenth of an inch in diameter, were selected for analysis, and gave as follows:—

Silica,	44·10
Magnesia,	40·05
Oxyd of iron and alumina,	1·15
Loss by ignition,	14·70
	100·00

The serpentine makes up about one-fifth of the rock. The portion soluble in nitric acid, consisted of carbonate of lime 55·13, carbonate of magnesia 44·87, being a pure dolomite.

5. In this connection I will cite from my Report of 1850, three analyses of serpentines from the Laurentian rocks. I and II are specimens of the retinalite of Thompson, which occurs at Grenville, disseminated in a white crystalline limestone. This serpentine has a hardness of 3·5, and a density of 2·476—2·525; lustre resinous, shining; fracture conchoidal, without any traces of crystallization; translucent; colour honey-yellow, passing into oil-green and olive-green. III is a serpentine closely resembling the last, from a similar rock at the Grand Calumet Island; it has a density of 2·362—2·381, and a pale wax-yellow colour.

	I.	II.	III.
Silica,	39·34	40·10	41·20
Magnesia,	43·02	41·65	43.52
Peroxyd of iron,	1·80	1·90	·80
Soda, (traces)		·90	....
Water,	15·09	15·00	15·40
	99·25	99·55	100·92

These serpentines, like the others from the same rocks already described, contain less oxyd of iron and a larger proportion of water than ordinary serpentine, approaching in composition to marmolite and deweylite.

Rensselaerite.—This mineral was first described and named by Dr. Emmons of the New York Geological Survey. It occurs, according to him, in beds or large masses among the Laurentian rocks of northern New York, and you have detected it forming a bed in the crystalline limestones of the same formation, on the thirteenth lot of the fifth range of Grenville, (*ante*, page 44.) Its structure is coarsely granular, the mass being apparently composed of cleavable crystalline grains, strongly coherent. Hardness, 2·5—3·0; density of masses containing a small amount of intermixed carbonate of lime, 2·757. (2·87, Emmons.) Colour greenish-white to pale sca-

green; translucent; lustre vitreous, shining on the cleavage surfaces, elsewhere waxy; sectile; the powdered mineral is unctuous, like steatite.

The rock contains a little carbonate of lime disseminated among the grains, but is a hydrated silicate of magnesia; the analysis of carefully selected portions gave me :—

Silica,	61·60
Magnesia,	31·06
Protoxyd of iron,	1·53
Water,	5·60
	99·79

No traces of lime, nickel nor manganese, were detected. The pulverized mineral loses no appreciable weight at 300° F., and by long continued ignition over a spirit-lamp, only 3·80 per cent., but by a white heat the loss is equal to 5·55 or 5·60 per cent. The renssellaerite is attacked and partially decomposed by boiling concentrated sulphuric acid; a portion thus treated, yielded to the acid 3·89 per cent. of magnesia. In this respect it differs from talc, and resembles an agalmatolite from China, examined by Wackenroder.

Cavities in the massive renssellaerite of Grenville are lined with crystals of the mineral, resembling exactly those occurring in similar conditions in Canton, New York, which are described by Dr. Beck as having the form and cleavage of pyroxene. Crystals from the latter locality, for which I am indebted to the kindness of Dr. Emmons, gave me by analysis, results identical with those obtained with the massive mineral of Grenville, viz.: silica 61·10, magnesia 31·63, protoxyd of iron 1·62, water 5·60 = 100·05. The crystals were from one-twentieth to one-tenth of an inch in length, translucent and pearl-grey in colour; they afforded no trace of lime.

Dr. Beck, in his analysis of renssellaerite, obtained: silica 59·75, magnesia 32·90, peroxyd of iron 3·40, lime 1·00, and water 2·85. The lime, and the large quantity of iron however show his specimen to have been impure, and his estimation of the water is probably inexact.

Rensselaerite appears then to be identical in composition with pure talc, from which it differs in crystalline form and in its relations with acids. Dr. Beck regards it as an altered pyroxene, but I see no reason, apart from its crystallization, for such a view, and am inclined to regard rensselaerite and talc as dimorphous conditions of the same silicate of magnesia.

A bed of rock having the characters of rensselaerite, and holding silvery mica and scales of graphite, occurs with the crystalline limestones in Rawdon, and a crystalline columnar variety, of what appears to be the same species, is found on Charleston Lake, in Lansdowne. Rensselaerite seems to replace in this formation, the talcs and steatites which are so abundant among the magnesian rocks of the metamorphic Silurian strata.

A yellowish-white earthy mineral is found filling fissures in the rensselaerite of Grenville. It is very soft and sectile; polishes under the nail, acquiring a waxy lustre, and adheres strongly to the tongue. Some portions of the mass contain disseminated scales of silvery mica. The mineral in powder is decomposed by boiling sulphuric acid, like serpentine, which it resembles in composition. It gave :—

Silica,	46·66
Magnesia (by difference),	38·05
Protoxyd of iron,	1·33
Loss by ignition,	13·96
	100·00

It is related by its physical characters to meerschaum or aphrodite, but contains less silica than these minerals.

IGNEOUS ROCKS.

I have now to present the results obtained in the examination of some of the trappean rocks of the District of Montreal. Among the great variety of intrusive rocks which penetrate the Silurian strata of this vicinity, there is a class known as *white traps*, which I have made the subject of a chemical and mineralogical investigation, and found to offer some interesting varieties.

1. A peculiar porphyritic trap from the Richelieu shales, near Chambly, is remarkable for the beautiful crystals of felspar which it contains. The base of the rock is of a pale fawn colour, and seems at first sight to be micaceous, but on closer examination it is seen to be made up entirely of lamellæ of felspar. Minute portions of pyrites, and grains of magnetic iron ore, are rarely met with, and small scales of what appears to be a dark-green decomposing mica, are very sparsely disseminated. The crystals of felspar, which are abundant, are sometimes an inch in length, and one-fourth of an inch in thickness, and are more or less modified, and terminated at both ends. The crystals are easily detached from the rock, and are yellowish and opaque on the exterior; but the interior portions of the larger ones are translucent and vitreous. The analysis of selected crystals gave me :—

Silica,	66·15
Alumina,	19·75
Lime,	·95
Potash,	7·53
Soda,	5·19
Loss by ignition,	·55
	100·12

The paste carefully freed from the crystals, lost by ignition 2·10 per cent. When treated with nitric acid, it effervesced slightly, evolving carbonic acid and red fumes, from the oxydation of the pyrites, and the decomposition of carbonates, and gave: carbonate of lime 1·70 per cent., carbonate of magnesia 0·98, and peroxyd of iron, nearly pure, 2·12 per cent. The residue from the action of nitric acid, dried at 300° F., gave by analysis as follows :—

Silica,	67·60
Alumina,	18·30
Peroxyd of iron,	1·40
Lime,	·45
Potash,	5·10
Soda,	5·85
Loss by ignition,	·25
	98·95

It will be seen that the crystals have the composition of orthoclase, and the paste, apart from the matter soluble in nitric acid, differs but very little from the crystals; it seems in fact a lamellar orthoclase, but contains a little more silica and less alkali than the crystals. The predominance of soda in the paste is also to be remarked. Delesse has observed as a general rule, that in those felspar porphyries which are without quartz, the paste, although differing but slightly from the crystals, contain a little more silica and less alkali than the felspar itself. (*ante* p. 382.)

2. The white traps of the Island of Montreal are more recent than the other igneous rocks, since they cut not only the limestones and shales, but the dolerites and melaphyres which penetrate these last. The first variety to be noticed is from a dyke near McGill College; it is a rock having the hardness of felspar, and a density of 2·617—2·632; colour white, passing into bluish and greyish-white; lustre, feeble, shining; translucent on the edges; fracture sub-conchoidal, uneven; texture, compact or fine granular; sonorous. Before the blow-pipe, it fuses with intumescence, into a white enamel with black points. The rock is divided by joints into irregular fragments, whose surfaces are often coated with thin bladed crystals of a mineral, frequently arranged in a radiated form, and somewhat resembling tremolite in aspect; from its blow-pipe characters however, it appears to be aluminous, and is probably a zeolite. Iron pyrites in small brilliant cubic crystals, often highly modified, is disseminated throughout the rock.

Examination showed that this rock was heterogeneous in its nature, and contained besides a felspar, portions of carbonates, and a silicate readily decomposable by acids. Its powder is attacked slightly even by acetic acid. A portion of the finely pulverized and sifted trap, was digested at a gentle heat with nitric acid of specific gravity, 1·25, until the red fumes from the oxydation of the pyrites had ceased. The liquid was then removed by filtration, and the residue boiled with a solution of carbonate of soda, which dissolved a portion of silica. The contents of the acid solution were also carefully

analyzed, and the following results obtained for the soluble matters of 100 parts of the rock :—

Silica,	1·43
Alumina,	2·43
Lime,	·60
Potash,	·40
Soda,	·98
Red oxyd of manganese,	1·31
Peroxyd of iron,	2·40

The amount of lime dissolved by acetic acid is equal to 0·45 per cent., or 0·80 per cent. of carbonate; the remaining 0·15 are probably present as a silicate. Acetic acid dissolves moreover, 1·5 per cent. of alumina and oxyd of iron, probably derived from a carbonate of iron, but a great part of this metal exists as sulphuret, in which state of combination the manganese also probably occurs. The whole of the manganese present is soluble in nitric acid, and while the white portions of the rock afford no trace of it before the blow-pipe, some minute dark-coloured grains were found to give an intense manganese re-action. Further examinations are however required to determine whether the manganese exists in the rock as a carbonate or sulphuret.

The white insoluble matter which had been treated with nitric acid and carbonate of soda, and dried at 300° F., was free from iron and manganese, and gave on analysis :—

Silica,	63·25
Alumina,	22·12
Potash,	5·92
Soda,	6·29
Lime,	·56
Loss on ignition,	·93
	99·07

Another determination of the alkalies, upon a portion of the rock which had not been submitted to the action of acid, gave potash 5·40, soda 6·49.

3. A specimen of a white trap from a dyke near the last, and scarcely distinguishable from it in appearance, gave to nitric acid, for 100 parts of the rock:—

Alumina and peroxyd of iron,	2·84
Red oxyd of manganese,	·87
Potash,	·25
Soda,	·21
Carbonate of lime,	3·33

The insoluble residue from the acid in this case, was not treated with a solution of carbonate of soda, but after drying in a water-bath, was submitted to analysis. It gave:—

Silica,	62·90
Alumina,	23·10
Potash,	2·43
Soda,	8·69
Lime,	·45
Loss by ignition,	1·40
	98·97

Another determination of the alkalies gave 2·28 of potash, and 7·95 of soda.

4. Another white trap from Lachine was similar in appearance to the preceding, but somewhat earthy in its aspect, and had an argillaceous odour. It contains disseminated pyrites, and occasionally, fissured crystals of a glassy felspar. The rock freed from these crystals, and reduced to powder, effervesces with nitric acid, which dissolves a considerable amount of lime, some magnesia, a little iron, no manganese, and only traces of alumina. 100 parts yielded of soluble matters:—

Lime,	4·14
Magnesia,	1·34
Peroxyd of iron,	1·47
Alumina,	·27

The above amount of lime equals 7·40 per cent. of carbonate. On boiling the pulverized trap with a solution of nitrate of ammonia, there was dissolved a quantity of lime equal to 5·33 per cent. of carbonate, or nearly three-fourths of the amount soluble in nitric acid. The dried residue from the acid gave by analysis: silica 58·50, alumina 24·90, lime 0·45, volatile matters 2·10, alkalies, by difference, 14·05=100·00. A portion of the alkalies was lost by an accident, but their proportions were determined upon the remainder, and the potash was found to be to the soda, very nearly as 2 : 3.

5. Another white trap from Lachine was concretionary, and stained, as if from infiltrated matters; the interior of the concretions resembled the last variety. It yielded to nitric acid, 3·50 of lime, 1·35 of magnesia, 1·32 of alumina, and 2·51 of peroxyd of iron; the residue then gave to a solution of carbonate of soda 5·0 per cent. of soluble silica. A partial analysis of this insoluble silicate shewed it to be a felspar, nearly resembling the last in composition; the potash and soda were however present in the proportion of 4 : 3.

6. Associated with the felspathic traps at Lachine, there occurs a dyke of another intrusive rock, which is very remarkable in its composition. It is brittle, breaking into angular fragments, and somewhat schistose in its structure. The eye distinguishes in this rock, a reddish fawn-coloured base, in which are disseminated small greenish-white rounded masses, often grouped, and seemingly concretionary in their nature. These greenish portions are sometimes half-an-inch or more in diameter, and cover from one-third to one-half of the surface, but are often indistinctly seen, unless the rock is moistened. The hardness of the different portions does not greatly vary, and is nearly that of apatite; the density is remarkably low, being only 2·414. The rock contains small cavities filled with calcareous spar, rarely stained purple; carbonate of lime also forms thin films in the joints of the mass. Fracture granular; lustre none; feebly translucent on the edges.

When reduced to powder, and mingled with nitric acid of specific gravity 1·25, a slight effervescence ensues, with abundant red fumes; the mass grows warm, and becomes gelatinous

like a zeolite, but on adding a solution of caustic soda to the jelly, the separated silica and the alumina are both dissolved by the alkali, leaving a white granular residue. This reaction is the same with the fawn-colored and greenish portions, but it is apparent that the amount of insoluble matter is greater in the greenish portions,

For the analysis of the rock, it was finely pulverized and sifted, treated with nitric acid as above, and digested for a few minutes at a gentle heat The soluble parts being then removed by water, the residue was warmed with a dilute solution of caustic soda, which readily dissolved the gelatinous silica, without attacking the silicate, as was evident from the fact that the alkaline solution contained besides the silica, a portion of alumina equal to only 0·40 per cent. of the undissolved mineral. This was found to be no longer acted upon by nitric acid, which only took up from it 0·12 of alumina.

The nitric solution was evaporated to dryness, and heated to decompose the nitrates of alumina and iron; the residue being digested with a warm solution of nitrate of ammonia, these bases were left behind. The lime was precipitated from the filtrate as oxalate, and the ammoniacal salts being then expelled by evaporation and heating, the remaining nitrates were by an excess of oxalic acid converted into oxalates, and these being changed by ignition into carbonates, a portion of magnesia was separated from the alkalies, which were estimated as chlorids. The alumina and oxyd of iron being dissolved in hydrochloric acid, left a little silica, which was added to that from the soda solution. The minute portions of alumina and iron from this, and from the subsequent treatment of the insoluble silicate by nitric acid, were united to the larger portions, and the iron separated from the alumina as sulphuret. This elegant process of Ste. Claire Deville offers great advantages for the separation of all the above-named bases.

The soluble portion of the rock was found to consist essentially of silica, alumina, and soda, with some oxyd of iron, traces of manganese, a little potash, and some magnesia and lime. The great part of the lime was evidently present in the

form of carbonate, for when a portion of the rock, which yielded to nitric acid a quantity of this base equal to 4·36 per cent. of carbonate, was boiled with nitrate of ammonia, there were dissolved 3·87 per cent. of carbonate of lime, besides a large amount of protoxyd of iron. The almost total absence of sulphur from the soluble portions, is shown by the fact that the alkalies separated by the process just described, did not contain an appreciable trace of sulphates, and we are led to conclude that the iron exists in the rock chiefly in the form of carbonate, whose oxydation gives rise to the red fumes evolved by the action of nitric acid. I have therefore calculated the lime and iron, as well as the trace of magnesia, as carbonates; although a little oxyd of iron doubtless gives its colour to the rock. The following are the results of the analyses of 4·0 grammes of the rock, as free as possible from the green portions, (I) and of 2·5 grammes, in which the green was intermingled, (II.)

	I.	II.
Insoluble silicate,	45·75	55·40
Soluble silicate, (by difference)	46·57	36·16
Carbonate of lime,	3·63	4·36
" " iron,	3·52	3·72
" " magnesia,	·53	·36
	100·00	100·00

In order to arrive at the composition of the soluble silicate, the amounts of the insoluble mineral, the silica, alumina, and alkalies having been carefully determined, and the lime, magnesia and iron calculated as above, the water was estimated by the loss. In this way the following results were obtained for the zeolitic portion of I and II.

	I.	II.
Silica,	51·96	51·66
Alumina,	24·42	24·88
Soda,	12·93	13·05
Potash,	1·15	1·28
Water,	9·54	9·13
	100·00	100·00

The amount of hygroscopic moisture in this trap is very small; a portion of I, in powder, lost only 0·20 per cent. after long exposure to a heat of 300° F., but 7·10 per cent at a red heat.

The insoluble silicate was submitted to analysis in the ordinary way, and yielded for I and II the following results:—

	I.	II.
Silica,	59·70	60·90
Alumina,	23·25	24·45
Potash,	9·16	....
Soda,	2·97	....
Lime,	·99	·45
Water,	2·23	2·10
	98·30	

It will be seen from the foregoing analysis that this trap is a mixture, in variable proportions, of a potash-felspar, with small portions of carbonates, and a zeolite, which is probably natrolite. The formula of natrolite requires silica 47·4, alumina 26·9, soda 16·2, and water 9·5, while analcime contains silica 54·6, alumina 23·2, soda 14·1, water 8·1. The composition of the zeolite of the trap as calculated above, is intermediate between these two species, but the readiness with which it gelatinizes by the action of acids, leads to the supposition that it is natrolite rather than analcime; If we suppose a portion of the felspar to be in such a state of decomposition as to be attacked by the nitric acid, we account for the excess of silica, as well as for the potash in the soluble portion.

The felspar of this last trap, and those of the preceding, resemble the felspar of I, in the almost complete absence of lime, and the large amount of alkalies which they contain. Like it, they are probably all to be referred to the species orthoclase; but they have undergone a commencement of that decomposition, which consists in the abstraction of a portion of silica and alkali, and the formation of kaolin, which is a hydrous silicate, containing silica 40·0, alumina 44·5, water 15·5. An admixture of this with the orthoclase will

explain the presence of water, and the diminished amount of silica, in the more earthy of these felspathic traps. The variations in the proportions of the two alkalies, observed in these different rocks, are remarkable.

The name of *phonolite* has been applied to some trappean rocks composed of felspar and zeolite, and may be used to distinguish this which we have just described, from the other felspathic traps. The composition of this phonolite is such, that I am disposed to look upon the water which it now contains, as having formed part of the mass at the time of its ejection, so that the felspar and zeolite were both formed during the cooling of the mass. The other felspathic traps may have been ejected under similar conditions, but the excess of silica has given rise to the formation of felspathic rocks, in which the zeolite is in smaller proportion, as in 2 and 3, or altogether wanting, as in 1. These considerations are closely connected with the now disputed question of the mode of formation of many intrusive rocks. The discussion of many points which are suggested in this connection, is however reserved for a future Report, which will include a series of analyses, as yet incomplete, of the intrusive rocks of Grenville.

I have the honour to be,

Sir,

Your most obedient servant,

T. STERRY HUNT.